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THE JUNE SCIENTIFIC MONTHLY

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THE SCIENCE OF EPIDEMIC DISEASES. DR. CHARLES V. CHAPIN 481

A VISIT TO FABRE'S HARMAS. PROFESSOR GLENN W. HERRICK 494

DAVID RITTENHOUSE—PIONEER AMERICAN ASTRONOMER. PROFESSOR W. CARL RUFUS 506

VISIONS AND DREAMS OF A SCIENTIFIC MAN. DR. PAUL R. HEYL 514

OPPORTUNITIES FOR RESEARCH IN MAMMALIAN GENETICS. PRESIDENT C. C. LITTLE 521

CAN WE LIVE LONGER:
A MEDICAL VIEWPOINT. COLONEL HARRY VANDERBILT WÜRDEMANN. A SOCIOLOGICAL VIEWPOINT. PROFESSOR R. D. MCKENZIE 535

THE OIL GAME. THE LATE EDWIN THEODORE DUMBLE 541

THE CONTROL OF CRIME. DR. EDGAR A. DOLL 551

LIKE FATHER LIKE SON-IN-LAW. DR. DONALD F. JONES 557

GARA CHEURFA. ALONZO W. POND 561

THE PROGRESS OF SCIENCE:
Hendrik Antoon Lorentz; The Revolution in Physics; The Fourth International Congress of Entomology 568

INDEX TO VOLUME XXVI 575

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THE SCIENTIFIC MONTHLY

JUNE, 1928

THE SCIENCE OF EPIDEMIC DISEASES

By Dr. CHARLES V. CHAPIN

SUPERINTENDENT OF HEALTH, PROVIDENCE, R. I.

It is difficult to define the word epidemiology, as this science is usually called. The common conception seems to be that it is a study of the incidence of the infectious diseases, of their causation and of their prevention. Recently there has been a tendency to extend it to include other diseases, such as cancer and the dietary diseases, as diabetes, pellagra and beriberi. The epidemiologist devotes himself chiefly to the study of disease as it actually occurs in human beings. The bacteriologist and the protozoologist are concerned with laboratory work on the causation of disease. Their business is to discover germs and learn their habits. Bacteriology has been called the handmaid of epidemiology, but it is rather an equal partner. The immunologist studies immunity and means for developing it. The statistician devises formulas and solves mathematical problems. All these may make excursion into the domain of epidemiology and often achieve valuable results. The epidemiologist is especially interested in methods to *prevent* disease, and much of his work is planned for this.

Epidemics have always afflicted mankind and medical men have continually sought to unravel their secrets, but until very recent times there has been little knowledge of scientific method. It is little wonder that preventive measures were based on theory and that theory was arrived at by *a priori* reasoning. Let us consider some of the theories that dominated preventive medicine until well after the middle of the nineteenth century, and are not without influence even to-day.

Ancient Theories

"Epidemic Constitutions"

The theory of "epidemic constitutions," as determining disease, is very ancient. It was clearly enunciated by Hippocrates, the "Father of Medicine," four centuries before Christ. Hippocrates taught that climate has a most important influence in the causation of disease. The air, its heat, its moisture, its impurities, the wind, its direction and force, are powerful factors. Three "constitutions," or types of climate, were described and also the diseases which were observed under each type. Other factors in the environment were discussed by Hippocrates in his chapters on airs, waters and places. Sydenham, in the seventeenth century, elaborated much further the theory of epidemic constitutions. Every known telluric or cosmic factor might be of influence, he said, and he even speaks of the "secret and inexplicable alteration of the air," and of "occult atmospheric influence." Even to-day there are a few epidemiologists who invoke such "constitutions" to explain the spread of disease, but most persons prefer to await the slow progress of inductive science.

Epidemic diseases, like prices, business failures, fashions and fire losses, show great variation in prevalence and by many are thought to occur in cycles, which can be correlated, more or less closely, with sun-spots, climatic conditions, etc. Studies of these relations have yielded little and mystical theories still less.

Whether or not the atmosphere causes disease, it has, through all time, been a popular theory that the air serves as a *vehicle* of infection.

Disease Not Air-borne

When people sicken of smallpox, plague, scarlet fever, measles or almost any infectious disease, it has been believed that it is because some virus, miasm or poison is borne to them by the air. It has been shown that there is some truth in this theory. Thus mosquitoes which transmit malaria are wafted by the air. The tiny droplets of saliva that carry infection may float, perhaps an arm's length, but rarely more. Perhaps infectious dust may be blown a short distance. We now know, however, that the air is a quite negligible factor in the distribution of bacteria and other disease-producing germs.

The Filth Theory of Disease

However, it is another, and far more unfortunate feature of the atmospheric theory of disease, which it is necessary to discuss. This is the supposed relation of decay and filth to disease. Doubtless this is an ancient theory, but until fairly modern times seems to have been advocated by laymen more than by physicians. It is set forth by Lucretius and by Pliny, and was even accepted by medieval monks, though they are not usually considered to have been especially hostile to uncleanliness. This filth theory of the origin of disease has had by far its greatest influence during the last 150 years. Dr. Benjamin Rush, of Philadelphia, was one of its most insistent advocates during the eighteenth century, and his high position as a patriotic citizen and his preeminence as a physician gave his words great weight. His views on this subject were bizarre in the extreme. Almost any organic matter in decay was believed by him to cause infectious and epidemic disease. Not only drains, cesspools and privies fell under his ban, but bilge water, decaying weeds and rotting cabbages were alleged to be the cause of fevers. Decaying matter was judged to give off a death-dealing something, but whether solid particles or gases, ferments or germs no one knew, though there were many guesses, but with few exceptions all were agreed that emanations from filth were the chief cause of infectious disease. Noah Webster, George E. Waring and other American lay writers, as well as the plumbers and sanitary engineers, were warm advocates of these ideas.

Early in the nineteenth century the great reform movement in England came into being. One of its leading figures was Edwin Chadwick. His first aim was to banish infectious disease. To learn how to do this he employed physicians to investigate. They agreed that air poisoned by filth was the cause. Chadwick's legal training did not fit him to act as a scientific arbiter, and, indeed, it is said that he would not listen to counter arguments.

The bacteriologists have taught us that the germs of a few diseases, as of cholera and typhoid fever, are carried from person to person through the medium of human excreta, but neither these germs nor any others breed in this or any kind of filth. The filth theory of the origin of disease is dead. Foul odors do not cause disease. The health officer is not interested in nuisances, unless they involve excreta disposal, nor in plumbing and drainage, unless sewage is likely to flow into a water supply.

The Theory of Contagion

As all are doubtless aware, most of the epidemic diseases are contagious. For the most part, physicians, until comparatively recent times, were not much inclined towards this theory. Hippocrates and Galen ignored it, and ancient and medieval medicine followed their teachings. Some of the Italian physicians, facing the epidemics of plague, during the Renaissance, as Frascatorius (1546), attributed the spread of the disease to contagion. Nevertheless, most physicians before and after him took little stock in contagion, but considered the atmosphere and "epidemic constitutions" as the chief cause of outbreaks of disease. Sydenham denied that even smallpox is a contagious disease, though he admitted that plague is. It is curious that plague was considered the one contagious disease, though in fact it is only rarely directly transferred from one person to another, but is primarily a disease of rats and usually extends to man by means of the bites of rat fleas.

The Jewish method of handling leprosy seems to have been the first application of the theory of contagion to the control of disease, and the Hebrew sacred writings doubtless had much to do with the attitude of medieval Europe towards this disease and perhaps towards plague, the care of these diseases being largely given by the monastic orders. As conspicuous examples of lay acceptance of the theory of contagion may be mentioned Thucydides and Boccaccio. Lord Bacon attributed the pestilence at the "Black Assizes" at Oxford in 1577 to contagion from the prisoners brought from the jail. Richard Mead (1673–1754), one of England's great physicians in the generation following Sydenham, firmly believed in the doctrine of contagion, though he admitted atmospheric corruption. During the nineteenth century, even to the time of Pasteur, the argument continued between the contagionists and those who believed in chemical changes in the atmosphere. Among brilliant examples of the former were Austin Flint, in this country, William Budd, of Bristol, England, and John Snow, of London. They demonstrated with certainty that cholera and typhoid fever are contagious diseases, and Snow argued most convincingly that the virus must be a living germ.

The Germ Theory

It is true that, from the golden age of the Greeks until the time of Pasteur, there have been a considerable number who have supported the germ theory of disease. With few exceptions, however, the theory led to little of practical value, since the nature of germs was entirely unknown. The first conspicuous example of correct deduction was the conclusion of Lister that putrefaction and suppuration in wounds are due to germs similar to those which Pasteur had shown to cause putrefaction and fermentation in broths and infusions. The wonderful success of Lister in applying this theory to surgery did more than anything else to incline medical men to look with favor on the hypothesis that infectious disease, as well as the infection of wounds, is caused by microscopic plants or animals. Still, this was but a theory, and while it remained such, gave rise to the most erroneous ideas as to the *de novo* origin of disease germs, their growth in filth and decaying matter, their wide distribution through the air and their tenacity of life, all of which did much to delay the application of effective methods of control.

Knowledge of Germs Takes Place of Theory

Pasteur and his followers changed all that. The year 1877 may be taken as the beginning of modern preventive medicine, for it was then demonstrated for the first time, beyond the slightest doubt, that anthrax, a disease sometimes affecting human beings, was caused by

living germs. Pasteur and Koch gave to the world the new science of bacteriology. The discovery of germ after germ came in rapid succession until now it has been clearly proved that about a hundred infectious diseases are caused in this way. Scientists often use the term "pathogenic micro-organisms," but I prefer to call them germs, or to use the rather better French word microbes. The majority of these microbes are bacteria, which are decidedly vegetable in character, others are protozoa, lowly forms of animal life, and some are microscopic worms. Bacteria received the earliest and most thorough study of all the germs. Bacteriology is an exacting science and the great number of laboratory men who soon appeared were imbued with the scientific spirit and were trained in logical methods of thought. A great volume of real knowledge of the nature of infectious disease soon took the place of crude theory. A new and wonderful aid had come to the assistance of epidemiology.

Germs Grow Only in Living Bodies

Although 1877, the year of Pasteur's great demonstration, has been named as the dividing point between ancient theory and modern fact in epidemiology, a long time elapsed before the old theories died and men were convinced of the truth of the new discoveries. Though there are even now some doubters, I will venture to mention here some of the more important truths which are now accepted by most epidemiologists as the basis of their science.

Fifty years ago it was vehemently debated whether the virus of disease does not arise *de novo*. When cholera appeared at many points in the Mississippi Valley, in 1873, some thought it imported, some believed that it was a product of our native filth. There was a similar dispute about yellow fever and typhoid fever. Even the germ theorists were in doubt. The question of the spontaneous generation of life has now been settled. All biologists are agreed as to that. Every disease germ, like every oak and every horse and every human being, is derived from ancestral germs, oaks, horses, humans. Now, if we find a case of cholera or yellow fever or typhoid fever, the epidemiologist knows that it must have come from a previous case, which it is the business of the health officer to find, if possible.

During all time it had been believed that an important if not the principal source of infectious disease is outside the body. The filth theorists thought that their miasms came from an unclean environment. The germ theorists thought that their germs bred outside the body in organic matter. They divided the epidemic diseases into two classes. If the disease poison, or germ, developed outside of the body they called it infectious; if it developed inside the body and was passed from person to person, it was called contagious. When the laboratory men began to study disease germs, they found that it was very difficult to grow them. Some they are even now unable to propagate. It became clear that most disease germs when they leave the body speedily perish, unless they are carefully nurtured in the laboratory by skilled technicians. In rare instances, they may grow for a short time in milk, or some other favorable medium, if all the conditions are right. Formerly, when the health officer found a person with typhoid fever or diphtheria, he sought for the source of the disease in a cesspool or sewer or dung heap. Now he knows he must search for it in some other human being. He knows that nearly all epidemic diseases are contagious. They pass from person to person, though often by a very circuitous route. It perhaps should be mentioned that the germs of a few diseases pass from the lower animals to man, but this is totally different from growing in water, soil, etc. The epi-

demiologist confines his attention to living beings, neglecting dead matter as a source of disease.

Importance of "Carriers" and "Missed Cases"

The laboratory has taught the epidemiologist not only where not to search for the source of disease, but where he should search. The laboratory has shown that when disease germs gain access to a person, they do not always make him sick. He may feel perfectly well, and go about, a healthy "carrier" of disease germs. Again the germs may make their host only slightly ill, causing such atypical symptoms that, even if seen by a physician, the disease would not be recognized, would be "missed" by the doctor. The laboratory has given the physician and the epidemiologist many methods of the greatest value as aids to diagnosis and which help greatly in the search for and study of carriers and missed cases.

Modes of Transmission

The Air

It is not only in finding the sources of infection that the epidemiologist has made great progress, but also in determining modes of transmission. It is not surprising that the air was long considered the chief vehicle of infection, and is to-day by a large portion of the laity. The adherents of the miasmatic theory of disease must necessarily look to the atmosphere as the bearer of the poison, and to the believers in the germ theory it seemed almost certain that such minute particles as germs must be freely wafted by the air even long distances. Since, at that time, the dangerous "carrier" was unknown, the fact that, often, no direct connection between cases of contagious disease could be established almost necessitated the theory that the contagion was air-borne. The demonstration by the early bacteriologists of the extreme smallness of bacteria served to strengthen this view. After a time, however, it was learned that germs are not given off into the air from moist surfaces, such as the membranes of the nose and mouth, the saliva, sputum, the body excretions or from the pustules of smallpox or the skin of scarlet fever patients, or from drains and cesspools. The chief way in which living germs can get into the air is in the tiny droplets given off in loud talking, coughing, etc., and rarely do these float more than an arm's length. It is true that germ-containing material may dry and become pulverized and float as dust, but most disease-producing germs speedily perish on drying, so that little harm is to be feared from dust. Thus the laboratory men have taught us that, under ordinary conditions, and except for a few feet around a coughing patient, the air is a negligible factor in the spread of infection. Lister feared the air as the chief source of wound infection, but modern surgery has shown that it is of little moment. As for our common contagious diseases, the epidemiologists have learned that they are rarely spread through the air, even in the home or in hospital wards.

Contact Infection

As a result of the collaboration of the laboratory and the epidemiologists, it has been fairly well determined that the common contagious diseases are spread chiefly by means of the quite direct transfer of quite fresh infective material from person to person. Doubtless, this is most commonly accomplished by the smearing of saliva and other body fluids on the fingers and on the countless objects which pass freely from hand to hand and from hand to mouth. This is the contact infection of the epidemiologists. Sedgwick, of Boston, was, perhaps, the first to call attention to this as observed during a village outbreak of typhoid fever. He says:

Children abound; and, as there are no fences, and because it is the custom, they mingle freely, playing together and passing from house to house. The families are of that grade in which food always stands upon the table; meals are irregular except for those who must obey the factory bell. The children play awhile, then visit the privies, and with unwashed hands finger the food upon the table. Then they eat awhile and return to play. Or, changing the order of things, they play in the dirt and eat and run to the privy, then eat, play, and eat again, and this in various houses and in various privies. For them, so long as they are friendly, all things are common—dirt, dinners and privies.

It will perhaps be remembered how our army was ravaged by typhoid fever during the Spanish War. A commission was appointed which started out with the idea that the disease must be water-borne. After much study it was decided that contact, direct or through the medium of food and flies, was the cause. Numberless epidemiological studies throughout the world have since made it certain that, in the absence of epidemics due to gross infection of water supplies, quite direct contact is the cause of most typhoid fever.

It is a surprise, and rather shocking, to learn that the human hands are so often the carriers of excrement, yet that it is so is abundantly proved by both bacteriologists and epidemiologists. Who can doubt that the fingers are ten times more likely to be smeared with saliva, and that they play the chief part in the spread of our most common diseases, in which the secretions of the mouth are the chief source of infection.

Other methods of transmission are by food and drink. Thus living typhoid germs or cholera germs may be carried many miles in milk or in water. The control of such modes of conveyance has resulted in an enormous decrease of those diseases which were formerly commonly spread in this way, though serious outbreaks sometimes occur even now, as is shown by the sad experience of Montreal with typhoid fever last year. Our knowledge of these modes of disease transmission are due almost entirely to studies by the epidemiologists.

Insect Transmission

Another fact of the utmost importance to epidemiology and to the prevention of disease is that certain contagious diseases are spread by biting insects. That insects play a part in disease transmission has long been suspected by a few. Mitchell, Nott and King in this country, Finlay in Cuba, Beauperthuy in South America, Manson in China, and others suggested the theory that mosquitoes transmit the virus of malaria and yellow fever and filariasis. Theobald Smith, in this country, in 1893, was the first to prove definitely that a disease may be transmitted by insects and to show how it is brought about. He demonstrated that Texas cattle fever is spread from animal to animal by a species of tick. Among the more important diseases transmitted by insects may be mentioned malaria, yellow fever, bubonic plague, typhus fever, dengue and African sleeping sickness. The development of our knowledge of these diseases furnishes the most fascinating chapter in medical history.

Immunity

From ancient times it has been known that in most contagious diseases one attack protects against another. Even influenza seems to produce some immunity in many of its victims, though it is usually far from complete or lasting. It is only in quite recent years that we have learned that it is by no means always necessary for a person to have a typical attack of a contagious disease to acquire immunity. Many times, persons have such a mild attack of diphtheria or scarlet fever that it is unnoticed, but the immunity may be as complete as that following a severe case. Again, it is now well known that, in most contagious diseases, a still larger portion of the population acquires the germs without

being sick at all. They are merely carriers, but are, nevertheless, immunized by their germs. It is believed that the amount of such natural immunity in a community is one of the important factors in determining the course of outbreaks. In large towns and cities, where one's contacts with others are so frequent, the number of such immunes is usually very much larger than in rural districts. In our mobilization camps recruited from rural districts, the outbreaks of contagious disease were sharper and far more extensive than in camps recruited from cities where so many had become immune.

It has been a common observation, and one that puzzled epidemiologists, that very young infants are less susceptible to contagious disease than they are a few months later. Now we know that the human body, when attacked by the germs of disease, begins to protect itself by the manufacture of antibodies, that is, antidotes against the germ poison. In diphtheria the antibody, or antitoxin, can be measured and we know that it continues in the blood long after the germs have disappeared. The blood of many mothers contains diphtheria antitoxin, and it passes to their unborn babes and is also furnished in the milk after birth. The same thing undoubtedly happens in many other diseases. This explains the comparative immunity of new-born children.

Ever since the discovery of vaccination against smallpox, medical men have sought immunization against other diseases, but it remained for Pasteur to show the way. Successful methods are now employed against several diseases, as diphtheria, typhoid fever, scarlet fever, dysentery, cholera, plague, measles and rabies. The laboratory man devises the methods and the health officer applies them, but to the epidemiologist falls the duty of appraising their real worth.

Field Work

Among the methods employed by epidemiologists in their study of disease, none has been so fruitful as what may be called field work. An exceedingly important study of this kind was made by John Snow, of London, about the middle of the last century. It was then almost universally believed that cholera is spread by a miasm from polluted soil. A severe, but sharply localized, outbreak of cholera occurred in St. James's Parish in early September, 1854. There were far more deaths than in any other similar district in London. A dozen different conditions, such as overcrowding, ventilation, cleanliness, sewers, water supply and nuisances had been investigated by the authorities without result. Snow obtained the location of all cholera deaths in the parish and plotted them on a map. There were several public wells which supplied different districts. It appeared that the great bulk of the cases was nearer the Broad Street Pump than any other. Investigation showed that many of the patients, a little outside the district, also went to the Broad Street Pump, because the water was colder. An almshouse and a brewery in the midst of the district, which had wells of their own, were almost exempt from infection. Two women in the West End who had water sent them from Broad Street developed cholera. A visitor from another town who remained in the district only twenty minutes, but who drank from the well, soon sickened of the disease. Snow rightly concluded that the well was the source of cholera, and had the pump handle removed and the outbreak, which was declining, soon ceased. Similar studies were made by Snow in connection with the various municipal water supplies of London, which are derived from various sources. By studying the distribution of the cholera cases, he found that the case rate

on one supply was five, on another seventy-one, on a third 288. The last was the most polluted, the first the least polluted. Similar studies all over the world have demonstrated the very great importance of water as a distributer of the germs of cholera, of typhoid fever and of certain other diseases.

At the time of the American Revolution there was a country physician in Gloucestershire, England, named Edward Jenner. He was an observing, thoughtful man, who had friends among the ablest medical men in London. He soon learned that the cows around about occasionally had a slight disease called cowpox, characterized by a few vesicles on the udder. Farmers and dairymaids occasionally contracted the infection, the vesicles appearing on the hands. It was a tradition among the country people that such persons could never contract smallpox. Jenner wisely did not disregard this tale, but for years kept his eyes and mind open. He found many persons who had had cowpox, but who never contracted smallpox, though exposed to it. At this time it was common practice to inoculate persons with smallpox, because they thus had the disease in much milder form than when they contracted it in the ordinary way. Jenner, as occasion offered, inoculated with smallpox many persons who had had cowpox recently, or in former years. None contracted smallpox. Jenner also found that cowpox, or vaccinia, as he named it, could be easily transferred from person to person. In May, 1796, he thus "vaccinated" a young boy and two months later inoculated him with smallpox. He did not develop the latter disease. A great many similar tests were made of the new procedure, both in Europe and in this country. Though an abundance of statistical evidence and personal experience, running over more than a century, has demonstrated the worth of this achievement, no more conclusive evidence was needed than the inoculation with smallpox of groups of persons living together, some of whom had been vaccinated and some not. It was invariably found that the vaccinated did not contract smallpox. The others did.

During 1889, influenza, which had been absent for many years, appeared in Russia and, within about three months, spread completely over Europe and America. Its progress was so rapid that to many it appeared that it must be airborne, even across great ocean stretches. Parsons, in England, determined to find out. He got the facts from great numbers of isolated communities, among others from four hundred off-shore lighthouses and lightships and from thousands of seagoing vessels. In not one instance was one of these attacked by influenza without human intercourse with the land. In a similar manner it was shown that isolated hamlets and dwellings among the Alps had no influenza until after the arrival of a visitor. Influenza is surely not an airborne disease.

There is one very important disease which I might be criticized for including among the germ diseases, for it is caused by an extremely minute worm. I refer to the results of infestation by hookworms. However, this so resembles the diseases we are considering that it is fair to refer to it here. These worms have long been known, and it was also known that they caused some disturbance of the health of workers in certain mines. No one imagined that the disease could be a scourge of whole countries until Ashford, one of our army physicians, in 1899, began to study the very prevalent anemia in Porto Rico. It was speedily found that, not only in Porto Rico, but in our southern states, and also in most warm climates, hookworms cause a vast amount of disability. A simple way was soon found to free the patient from the worms. It was also found that if human excrement is properly disposed of, there will be no hookworm disease, but to con-

trol it simply and economically has required an immense amount of epidemiological study of the distribution of the worms, of the temperature and rainfall, of the nature of the soil, of the manner of infection, of the amount and persistence of the infestation and of the success of methods of treatment and of excreta disposal. To discover the essential cause of a disease is one thing. To find effective means of control is quite another. To plan and test such means is the province of epidemiology.

Animal Experiment

Much field work, as in some of the examples just given, was done before the germs of the diseases were discovered, indeed, before microbes and their disease-producing powers were known at all, but it is, nevertheless, true that the labors of Pasteur and of his countless laboratory followers have piled up a wealth of knowledge about disease germs which has been of tremendous value in all epidemiological study. The greater part of this knowledge has depended on the use of small animals, as mice, guinea-pigs and rabbits. Only a very few diseases spread naturally among both humans and animals. In this climate tuberculosis is almost the only common disease which does so; nevertheless, such animals may be of the greatest use. Thus, though guinea-pigs are not naturally subject to diphtheria, the inoculation of the germs causes characteristic symptoms, and the discovery of antitoxin and immunization against this disease depended almost entirely on the use of these animals. Also animals have been much used for feeding and inhalation experiments for the study of the modes of transmission of tuberculosis.

Bubonic plague, which is such a tremendously destructive disease to man in many parts of the world, is common also among various kinds of animals; indeed, it is primarily a disease of rats, secondarily attacking human beings. Probably the plague problem would never have been solved without the discovery of the germ of the disease, which was made simultaneously by a Japanese and by a Frenchman, in 1894, but this discovery itself amounted to little. It would be interesting, indeed, to follow the various field observations which led to the theory that the disease is carried from rats to man by fleas, but space forbids. I will simply refer to the brilliant experiments of the English Plague Commission, which were carried out in India and which demonstrated the fact beyond question. The inhabitants of a plague-stricken village had abandoned it, as often happened. Guinea-pigs were then allowed to run about some of the houses. Many of them speedily died of plague and rat fleas infected with plague germs were found upon them. Other guinea pigs were exposed in boxes covered with netting to exclude fleas and none had the disease. Others protected from fleas by tanglefoot placed around the cages also remained well. Others, still, were exposed to soiled clothing in infected houses, but remained well, except in the few instances in which fleas happened to remain. The problem of plague was, after centuries of speculation, solved by a few simple experiments.

Experimental Epidemiology

This is the technical name of a rather new method of study which is proving of very great value. It is less than ten years since Topley, in London, began a series of experiments dealing with the spread of contagious disease among mice. Occasionally experimental epidemics among laboratory animals had been studied before, but this was the first time an extended series of experiments had been carried out in the attempt to solve some of the general problems relating to the rise and fall of epidemics. Previous work had been to solve some particular problem concerning some particular disease. It is

curious that, a little later, a quite similar series of experiments was begun at the Rockefeller Institute, in New York, without any knowledge of what was being done in London. It is also of interest that, since the two groups of investigators became acquainted with each other's studies, they have worked on their problems in complete harmony and with constant cooperation, though the character of the experiments on the two sides of the ocean has varied considerably.

When a cage of mice is infected with mouse typhoid, or certain other diseases, a little time must elapse before the epidemic gets into full swing. After awhile it begins to decline and gradually dies out. The reason for its dying out is that the surviving mice have been immunized by non-fatal doses. Now, if a batch of susceptible mice are added to the immune herd, in a short time the added mice begin to die and another epidemic occurs. At first the survivors of the first outbreak resist the new wave of infection, but after a time some of them, too, succumb. Much light has already been thrown on the problem, but many of the facts observed in these experiments are difficult to understand, and they are still under investigation.

Since the development of bacteriology many have been inclined to forget that, as it takes two to make a quarrel, so it takes two to make a disease, the microbe and its host. There is a constant struggle between disease germs and the bodies of animals and of human beings that they invade. There is also a tendency for an equilibrium to become established. The germs kill off the most susceptible and immunize the more resistant. In some of the resistant individuals the germs become more or less firmly established, thus producing carriers, which carry over the virus until more susceptible material is available. This group of experiments has forcibly called attention to this tendency to equilibrium, and to the importance of carriers and of herd immunity in the rise and fall of outbreaks of contagious disease. Much light also is thrown on changes in the virulence of the germs and on the effects of the dosage of the germs and on the diet of the animals.

Commander Dudley, of the British Navy, has been making careful studies of outbreaks of diphtheria, scarlet fever and influenza on shipboard, and in boarding schools, where conditions can be controlled, somewhat as in the cages of mice. He comes to conclusions very similar to those of Topley and Flexner and their coworkers. As in mice, so in humans, carriers play an important part in the causation of outbreaks. Natural immunization, largely by doses of the virus too small to be infective, increases the immunity of the group and brings outbreaks to a close and then the addition of newcomers starts the disease again. Dudley, more convincingly than any one else, showed the immunizing effect of continued slight exposure to cases or carriers. In the Royal Naval School at Greenwich he found the immunity to diphtheria, as indicated by the Schick test, significantly higher in boys who had been through an outbreak of diphtheria in the school, without themselves contracting the disease, than it was in a comparable group of boys who had not been similarly exposed to diphtheria.

Experiments on Human Beings

A number of important epidemiological facts have been learned by experiments on human beings, sometimes accidental, sometimes deliberately planned. Scores of times in various laboratories pure cultures of disease germs have been accidentally drawn into the mouth or nose of some one, or have gotten into cuts in the skin and have caused disease. Cholera, typhoid fever and diphtheria have thus been caused in different parts of the world, and no better proof is

afforded that these germs are the true causes of these specific diseases. There is a considerable list of disease germs, the virulence of which for human beings has been proved in this manner.

At other times the infection of human beings has been intentional. Many investigators have made tests on themselves, and many persons have volunteered for the experiment, sometimes with and sometimes without pecuniary reward. The most conspicuous example of such experiments is that made during the study of yellow fever by our army commission in 1899 and 1900. The observations of Dr. Carlos J. Finlay, of Havana, had shown that a certain mosquito, now called *Aëdes egypti,* is particularly numerous where yellow fever abounds, and he suspected that it was the cause of the disease. Henry R. Carter, of our Public Health Service, had observed the curious fact that, though the incubation period of yellow fever is about five days, there was always an interval of fifteen to twenty days after yellow fever was brought to a new place before secondary cases developed. The commission thought that perhaps this might be due to the time necessary for the growth of the germs in the mosquito, so they determined to take up first the mosquito question. Yellow fever was continually taking its toll of victims in Havana, so that considerable risk was warranted. The question of mosquito transmission could be speedily settled by testing it on human beings. Two members of the commission and a number of other volunteers allowed themselves to be bitten by mosquitoes which had previously bitten yellow fever patients. Most of the men developed yellow fever, and some of them died, including Lazear, of the commission. Their sacrifice has already saved vast numbers of lives and untold wealth. In all, twenty-four persons acquired the disease by voluntary exposure to the bites of infected mosquitoes. The experiments carried on in the most careful manner proved, beyond question, that this disease is spread from man to man by the bites of mosquitoes. They did not prove that the disease was not also spread by means of the excreta or the effluvium therefrom, as was believed by practically every one who had experience with this disease. So rooms were prepared in which the floor and bedding were soiled with vomitus and feces from patients, and heaps of clothing from the dead were thrown in the corner. Volunteers slept in these rooms night after night. Not one developed the disease. The mosquito theory had been established. Gorgas put it to a practical test. He eliminated *Aëdes egypti,* and yellow fever, for the first time in 150 years, disappeared from Havana. The great terror of the Western Hemisphere has been banished from the American continent, except for one small area in Brazil. Epidemiology did this without any knowledge of the nature of the germ which causes the disease.

In a similar manner a large number of persons assisted in the demonstration that malaria is mosquito-borne by submitting themselves to the bites of infected insects. The most striking proof was afforded by shipping from Italy to England (where there was then no malaria) mosquitoes which were infected with malaria in Italy. Mr. P. T. Manson, of London, son of Patrick Manson, who had done so much to help Ross in his malaria studies, allowed himself to be bitten and developed malarial fever, and malarial germs were found in his blood.

Intentional inoculation of supposedly infectious material into human beings has also been tried in scarlet fever, measles and influenza.

Mathematics

The importance of statistical records in epidemiology is very great. They are, in fact, its chief raw material.

Often these data are of value just as they are, or after being subjected to very simple mathematical treatment. Thus, a health officer of a growing city who can show from his death records that there were 122 deaths from typhoid fever in 1882, and none in 1922, has no need to do more to prove that fatal typhoid fever has shown a phenomenal decrease. If the city has been growing and the decrease in deaths has not been large, it may not be so evident, and he may have to calculate the rate, that is, the number of deaths per one hundred thousand of the population, before he can be sure of the decrease and especially of its amount. Again, suppose a health officer wishes to know how often a second case of infantile paralysis occurs in a family. If he has had an outbreak of one hundred cases, and four of them are secondary cases, is he justified in assuming that four is the correct percentage of secondary infections? By no amount of thought can he determine whether it is or whether he ought to have twice or ten or a hundred times as many cases before he can be reasonably sure of the secondary attack rate. There are, however, mathematical formulas which will inform him, within reasonable limits, how large a sample he ought to have. If one thousand soldiers have been immunized against colds and have been followed through the winter, and it is found that 586 contracted a cold, while 702 of one thousand not immunized soldiers living under the same conditions suffered from colds, is the difference sufficient to warrant the conclusion that such immunization is of value? Here again statistical methods will help in determining the probability. In studying the possible causative relation of events, mathematics are of much value to the epidemiologist.

There are, however, certain persons who have gone very far in their attempts to solve epidemiological problems by means of mathematical formulas. Using the statistical material furnished by health officers and registrars, they, by such formulas, attempt to solve some of the most difficult problems of causation, such, for instance, as the causes of the great decline of the tuberculosis death-rate. Again, they claim to be able to establish the true periodicity of diseases. Thus it is alleged that influenza occurs every thirty-three or sixty-six weeks. In the opinion of many persons competent to judge, it is believed that some of these refined statistical methods are not suitable for the solution of many of the health officers' problems, and also that they have not, as yet, led to establishing many epidemiological facts of importance.

In the statistical analysis of records of cases and deaths it must also be borne in mind that the conclusions reached are only as sound as the data on which they are based. Thus, if three fourths of all cases of scarlet fever are reported in one city and two thirds in another, it is obvious that no refinement of statistical method can make the two series of figures comparable, so long as the completeness of the reporting remains unknown. A certain familiarity with statistical methods will help the epidemiologist to avoid many pitfalls in the interpretation of his figures, but it is upon the proper selection of data, the careful use of controls, and interpretation consistent with the known facts of the disease in question that the soundness of epidemiological studies really depends.

Results

The study of epidemiology has profoundly modified our methods of dealing with contagious diseases. The old methods of arbitrary detention and destructive disinfection of incoming vessels has given way to effective inspection and removal of contacts. Fumigation is reserved only for plague ships, and is not destructive. On shore the fumigation of dwellings and schools also has been

abandoned. The useless search for disease in drains and cesspools has ceased, and the search for human carriers in homes, schools, institutions and dairies finds the true sources of infection and permits control. A wet sheet is no longer hung before the door of the sick room, but the attendants are taught to wash their hands even as the surgeon does. Persons do not cross the street when they see a scarlet fever warning sign, nor is it necessary to place an isolation hospital in a lonely spot. All our methods of isolation are becoming more rational and effective and less of a burden on the afflicted.

Cholera is no longer feared and typhoid fever is a vanishing disease. The discovery of the germs of these diseases has been of great assistance to the epidemiologist, but before the days of Koch and Eberth the source and mode of spread of these scourges had been largely worked out. The efficiency of water filtration, of pasteurization of milk and of immunization have been tested by the epidemiologist, and their worth has been proved. Epidemiology has furnished the weapons to the health officer, and politics alone can prevent their successful use.

The imminent extinction of yellow fever is due entirely to epidemiological studies.

The ancients could combat malaria only by drainage, a measure rarely feasible. Epidemiology, by making use of the discovery of the germ by Lavaran and of the infecting mosquito by Ross, has studied the vast problem in detail, and has devised and tested other methods of control, so that now it is possible to rid even large rural areas of this disease, where even a few years ago the task seemed hopeless.

For sixty years the discovery of hookworms did little for mankind. The epidemiological studies begun by Ashford, and continued by the Rockefeller Foundation, have brought good health to millions of men and women.

Besides these especially noteworthy results, the scientific study of the causes and of the modes of transmission of many other infectious diseases have been of immense importance in their control. Moreover, epidemiology has not confined itself to this class of diseases. Pellagra was formerly thought by many to be a germ disease, but careful epidemiological studies have shown that it is not, but is due to some dietary deficiency, and, though much more needs to be learned, the disease can generally be prevented and cured, too, by a proper diet.

Even if we are still helpless when influenza comes, if we can not stop the spread of measles, or whooping cough, if pneumonia remains a very serious problem and we are still in doubt how much the spread of scarlet fever and diphtheria has really been checked, let us take courage. Remembering what has been accomplished during the last fifty years, are we not justified in the hope of other great advances in the half century next to come?

A VISIT TO FABRE'S *HARMAS*

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Now that scientific research has accumulated, almost within the last quarter of a century, an entirely new and astonishing amount of knowledge concerning the vital relation to man of those small creatures we call insects, the world has become much interested in the activities of these animals and in the rôle they play in the world. Since it has been conclusively demonstrated that fleas, mosquitoes, houseflies, body lice and other insects carry the unseen organisms that cause some of the most malignant diseases to which man is subject, we have begun to look upon these tiny creatures with more than passing interest; and upon the men who are devoting their lives to a study of them with considerable respect. But long before investigators discovered that insects are the carriers of disease-producing organisms which interfere seriously with our health and happiness, there were men who were interested in these small animals and were painstakingly observing them and their ways, solely because of their great inherent scientific interest—because they exhibit a most amazing variety of habits, adaptations, instincts and modes of living. Such a one was Jean Henri Fabre, of modest, humble character, but profoundly devoted to a search for the truth.

Victor Hugo, in an appreciation of Fabre, called him "the Homer of the insects," while Edmond Rostand, in a subsequent eulogy of the man, bestowed upon him the title, "the Virgil of insects." Neither of these titles is adequate, for each expresses but one of Fabre's gifts, namely, that of a story-teller and writer, thus failing altogether to convey any notion of his other great quality, his transcendant obsession for observing the ways of nature. From his childhood Fabre was obsessed with a passionate curiosity concerning the lives and ways of living creatures, especially insects. Born of illiterate parents who utterly failed to comprehend their remarkable child and whose superstitious notions were aggravated by the worthless stones and queer creatures the "little simpleton" brought home in his pocket, as though "some one had cast an evil spell over him," he pursued his way without sympathy, amid much unrequited toil, persistently following his search for truth to the very end of an eventually fruitful life. His early boyhood was spent on the high, barren, sterile pasture lands of Provence in Southern France, where the struggle for existence was terrific.

Indeed Fabre's whole life was a tremendous physical struggle, yet it was, from his young manhood at least, one succession of happy, glorious, exciting days, intellectually. Probably most of us in our usually superficial way would say that Fabre was too impractical to meet with any degree of material success the struggle for existence with which he found himself confronted. The truth is, his spiritual qualities were too insistent and his absorption in a persistent search for the truth too complete for him to give much material thought or effort to the morrow of life. As a result, the grim specter of want skulked just around the corner from his door nearly all his long, eventful life. But no one can say that the man who has the fire of scholarly research and answers

to its call within him could not attain material success if he cared to put away the former and enter with zeal upon the pursuit of the latter. It is not too much to say that the human qualities requisite for success in either field are much the same—singleness of purpose, fidelity to truth, imagination, faith, work, and again, work. It seems passing strange that a man with the high ideals of Fabre and the courage to follow them against all adversity should suddenly emerge from such a humble, barren, inhospitable environment and stand like a towering, weather-beaten but sunlit butte on a bare, lonely plain. He was unable to explain it, for he always believed himself to be a living refutation of that portion of the theory of evolution which holds that heredity and environment largely determine what a person's character and ability shall be; but de Vries' work on mutations and the knowledge of Mendel's experiments on the dominant and recessive quaiities of hybrids came too late for Fabre to appreciate the full significance of them and their possible application to his own existence.

Nimîs, the largest city in the general region of Provence, was the terminus of the great Roman road that left the imperial city through the Porta dei Cavalleggeri over the Aurelian way, skirted the Mediterranean through northern Italy and passed along the Riviera of France for the most part where that fine modern road, the Grand Corniche, now runs. Over this road during the first centuries of the Christian era came the flower and culture of Rome, pouring into the Valley of the Rhone which became the center of Roman civilization in Southern Gaul, with Arles as the capital and with Nimîs, Avignon and Orange as outlying cities. Hardly had the development of this Roman province come to its fruition before the cruel, crushing Goths arrived in the fifth century and overran Provence, capturing Arles and completing the destruction of this outlying seat of Roman civilization. The triumph of the Goths was short-lived, however, for they were overwhelmed some two hundred years later by the Saracens, who in turn were expelled by Charles Martel in 739 when the country came again under definite Frankish rule. Amid all this welter and chaos of races, in which there must have been more or less mingling of many bloods, who can say that an intellectual strain of Roman culture, recessive for centuries, did not suddenly reappear in Fabre, or that its incipient potency did not burgeon forth as a mutation to produce this naturalist? We only suggest the idea, we do not argue it, for it matters little how he came, but that he was here does mean much to humanity.

Fabre's schooling during his early boyhood days was meager, poor in quality and obtained at a sacrifice of physical strength. His thirst for knowledge and his great industry carried him through these early years and in 1842, at the age of nineteen, he acquired a diploma to teach in elementary schools and obtained a position as teacher in the "college" of Carpentras. Fabre was a born teacher and at once gained the interest and respect of his pupils by the vivid, living manner in which he taught chemistry, physics and geometry. In the meantime, ambitious for a professorship in a real college, and imbued with a desire for research, he studied during the long evenings and every spare hour of his holidays to perfect himself in mathematics and the sciences while he struggled to maintain life on a pitiful salary of seven hundred francs a year. The opportunity for which he was preparing came at last, for early in 1850 he was invited to occupy a vacancy in the department of physics and chemistry in the College of Ajaccio, in Corsica, where he became greatly interested in the flora of the island and made an extensive collec-

tion of the native plants. Suffering severely from malaria, however, he was glad, after three years of service at Ajaccio, to accept a call to the chair of adjunct professor of physics in the Lycée at Avignon. Thus he returned to the region in which he had been born and reared. Here he taught and carried on his laborious researches on living insects, happy in the opportunity to live, to "pry into life," and to observe nature under the blue sky of his native land; for it was while in Avignon in 1854 that he chanced to fall upon an entomological treatise by Léon Dufour which so enthused and engrossed his mind that he at once began those remarkable studies of his on the habits of living insects which finally came to occupy his whole time and thought to the very day of his death.

As a teacher, Fabre thought that natural history should be taught from nature itself and not from books. He also believed it might be taught to girls as well as to boys. In this respect he was far ahead of his time and, as the sequel shows, suffered for it from the persecutions of those bigoted, intolerant individuals who were not able to see beyond the tiny horizon which bounded their restricted lives. The minister of education, Monsieur Victor Duruy, instituted about this time in the schools of France courses for the higher education of girls, a distinct innovation for those days. In the Lycée of Avignon these courses in the physical and natural sciences were assigned to Fabre. The girls were eager, enthusiastic and receptive, but Fabre soon found that to teach girls the composition of air and water, the nature of electricity, the manner in which a seed sprouts or a blossom opens was an abominable corruption of virgin innocence and must therefore be stopped by fair means or foul. Unfortunately, Fabre had no lease of the house in which he lived, a condition of which his persecutors took full advantage; for one morning in the summer of 1870 the bailiff appeared at Fabre's home and bluntly informed him that he must vacate the premises within four weeks from date or his household goods would be set into the street. By chance the only house he could find available was one in Orange, a small city some twelve miles north of Avignon. Thence his family and household goods were removed, thanks to the aid of a generous loan of three thousand francs made by John Stuart Mill, who had spent many happy days with Fabre roaming through the fields about Avignon where they had together collected the native flora in which both were interested. Although Fabre still held the curatorship of the Requien Museum at Avignon which furnished a small yearly stipend he had now to look about for further sources of income for the support of his increasing family. Thus necessity forced him to begin that series of elementary textbooks of science which, written in his inimitable style, proved so popular with both young and old that the royalties from the sale of them were, at that time, and to Fabre, unexpectedly remunerative. Here also, at Orange, was begun his great work, the "Entomological Souvenirs," which brought world-wide recognition and permanent fame to the author. His residence in Orange, however, did not prove to be permanent, for he was destined to make one more move which he determined would be his last one. The cause of this final change was characteristic of the man and was the natural outgrowth of his love for nature and his desire to observe the habits of insects unmolested by curious passers-by.

The road leading up to the house which Fabre occupied in Orange was bordered on either side by a row of fine plane-trees which had afforded welcome shade in summer and homes for birds, cicadas and other insects in whose songs

JEAN HENRI FABRE.

THE FABRE FAMILY

FIRST ROW, SITTING—MLLE. FABRE (CARETAKER OF HARMAS), FABRE'S BROTHER, J. H. FABRE, MADAME FABRE (SECOND). SECOND ROW, STANDING—MLLE. FABRE, DAUGHTER OF THE SECOND MRS. FABRE, PAUL AND EMIL FABRE (SONS OF FABRE), EMIL FABRE'S SON, MLLE. FABRE, DAUGHTER OF THE SECOND MRS. FABRE. PHOTO TAKEN IN 1905 OR 1906.

and presence he so delighted; but the owner of the place, having little of the romance and love of nature in his soul, appeared one morning with workmen and tools and felled and disposed of every one of the cherished plane-trees. To Fabre it was an act of vandalism and so disheartened and disgusted him that he resolved then and there to acquire a place of his own where no trespasser could interrupt his observations and where no ruthless owner could cut and destroy. Thus was born the idea of the "Harmas," which Fabre was now enabled to make a reality through the income from his writings. From his love of the fields and his desire for quietness he went to the little village of Sérignan, five miles northeast of Orange, and purchased a deserted house with its bit of neglected and overgrown garden situated some little distance from the center of the village, in a quiet, somewhat isolated spot. Here, then, at last, he had acquired "the bit of land long cherished in his plans to form a laboratory of living entomology, the bit of land . . . in the solitude of a little village," his "harmas," which was to become, all unsuspected by him, the mecca of many an admiring fellow-worker.

On a beautiful day in April the writer, on a pilgrimage to Fabre's Harmas, alighted at the station in the quaint old city of Orange with its interesting re-

mains of a Roman Theater and its amazingly well-preserved Arc de Triomphe. By dint of inquiry we learned that an autobus made two round trips daily between Orange and Vaucluse, the latter town of particular interest because it was here that Petrarch spent several years of his middle life in the solitude of his quaint old home not far from the shimmering pool from which the river Sorgue takes its source. In going from Orange to Vaucluse the bus passes through the village of Sérignan, where it stops long enough to discharge and receive its infrequent passengers and to deposit the morning's mail. Leaving La Gare of the P. L. M. at Orange, we passed uptown by way of the Hotel de La Porte et des Princes, along the Rue Victor Hugo, around the Arc de Triomphe, and on out into the country where the hard, white road, lined on either side with plane-trees, led through olive orchards and vineyards until suddenly it came into the *Cours* J. Henri Fabre; and in a moment more we found ourselves in the village square, facing the bronze statue of Fabre reposed in a sitting posture and wearing the broad-brimmed hat he always affected.

Sérignan is a sleepy little cross-roads village, composed mainly of petty tradesmen and mechanics—a blacksmith, a cabinet maker, a wheelwright, a bicycle mender, a carpenter, a baker—whose main business seemed to be to serve the peasant farmers in the immediate neighborhood. There is the inevitable church, cathedral-like in its dim, cold, spacious interior, the Hotel de Ville, the Poste et Télégraphe, a tiny shop displaying a few cheeses, some dried fish and a few staple vegetables and one equally tiny shop in which the village housewives purchase needles, thread, yarn for knitting, towels and other simple household necessities. The streets are narrow and crooked, the houses are old, quaint stone and tiled affairs with a few tiny windows and are built in all sorts of shapes and set in apparently any position that suited the fancy of the builder. The only modern touches in the village were

THE WALL OF THE SIDE OF THE HARMAS NEXT TO THE STREET.

THE FRONT OF FABRE'S HOUSE IN HIS HARMAS AT SÉRIGNAN.

some wireless antennae stretched across the roofs of half a dozen houses, an airplane droning overhead, and the small wasp-like autos kicking up clouds of dust as they honked through the streets.

Suddenly, as I stood taking a snapshot of the village square and statue, a kindly Frenchman appeared on a wheel, quickly dismounted and came directly to the stranger, for he too was a photographer, and an admirer of the man to whom he was sure the American had come to pay homage. Monsieur Raymonde quickly introduced himself and enthusiastically offered to conduct me to the Harmas, for he knew the way, was acquainted with Mademoiselle Fabre, and, what was more wonderful to the stranger, he had often visited Fabre while the latter was living and working. Thus I was personally conducted to and through the Harmas and, at the same time, entertained with reminiscences of the entomologist whose laboratory I had come to visit. From the

village square we turned back toward Orange for perhaps three quarters of a mile until we came to an isolated place among the unkempt fields somewhat pretentious in appearance, for it was surrounded by a high solid stone and concrete wall. Just within the wall in the corner facing us as we approached was a cluster of the dark, conical cypress trees so characteristic of Southern Europe through which one could see the tiled roof and patched stucco walls of the dwelling. We passed down a narrow path along the north side of the harmas until we reached a plain wooden door set in the wall. My guide pulled the end of a wire beside the door and we heard a bell tinkling in the distance which was promptly answered by a tiny servant girl, who ushered us into the quiet protected precincts of the bit of land where Fabre spent thirty-eight years of his later life observing the insect inhabitants and writing of their curious lives. The word, *harmas*, as he explains, is "given, in this district, to an untilled, pebbly expanse abandoned to the vegetation of the thyme. It is too poor to repay the work of the plough; but the sheep pass there in spring, when it has chanced to rain and a little grass shoots up. . . . This cursed ground, which no one would have had at a gift to sow with a pinch of turnip seed, is an earthly paradise for bees and wasps." Such it was when Fabre found it, but on this April day we stepped through the opening in the wall into another world, a world fragrant with the aroma of the native spring flowers, quiet, peaceful and permanently restful.

As we passed through the tiny doorway we entered a broad lane, or way, which, beginning beneath a locust tree entwined with climbing roses, led straight on by the great water basins on the left and passed beneath two fine plane-trees in front of the house where it widened a little, and then continued on between rows of blooming lilacs on either hand to the great iron gate in the front wall which gave entrance and exit when needed but was opened only on special occasions.

At the house we were received by Mademoiselle Fabre, the oldest daughter, who has been designated caretaker of the place now that it has become a public memorial under the care of the state. She had chairs brought and we all sat down under the wide plane-trees in front of the house, where we chatted about her father and his work. Mademoiselle is petite, with whitening hair, and rather frail in appearance with her thin and wrinkled face and hands, but her mind is alert and questioning. She evinced none of the usual French vivacity of manner, yet it was evident that she was proud of the visit from the American, feeling that it was an act of homage to her father.

The broadened space in front of the house was shut off from the garden of the harmas by a low stone wall ornamented with urns and trailing vines. A passageway in it led down to the brimming pool with its tinkling fountain where aquatic insects were skipping over the surface and diving into its depths. We were scarcely more than seated before Sophie, the venerable tortoise who has been since the garden first began, came stumbling up the stone step from somewhere in the tangled shrubbery below, and made straight for the felt slippers of Mademoiselle at the soles of which she nibbled, whether as a request for food or as a turtle's mode of caress I could not tell; and if Mademoiselle knew she did not explain but gently shoved her turtleship away as the attack was renewed or lifted her feet to the round of the chair out of reach.

The house is a simple, square, two-story dwelling with a wing on either side, of which the left one constituted Fabre's laboratory, supplemented by the

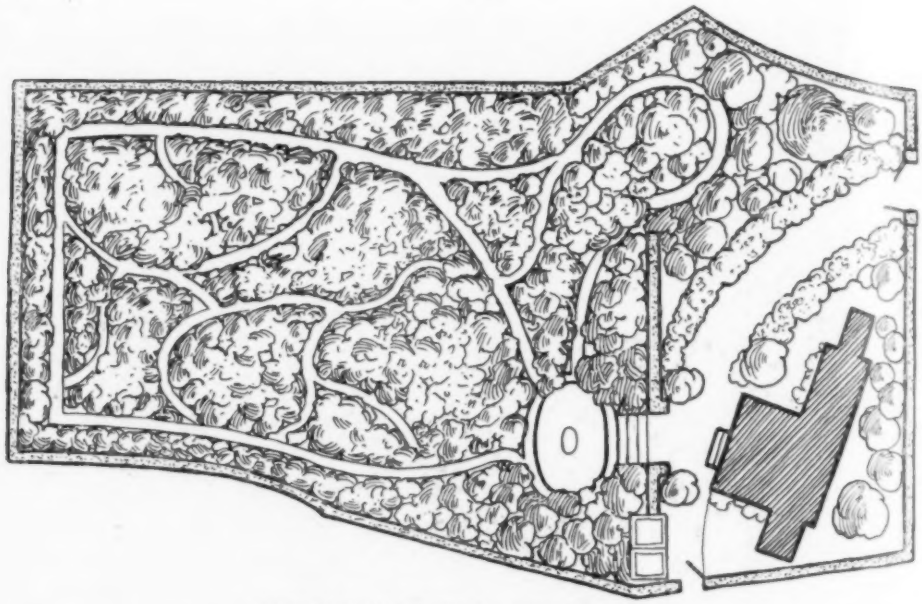
THE ELL OF FABRE'S HOUSE IN WHICH HE HAD HIS WORKROOM OR LABORATORY.

glass house adjacent to the south side. Fabre's real workroom was on the second floor of this wing. It is a room about fifteen by twenty feet with two small wooden shuttered windows on the east. In the middle of the room stands a long table on which repose some small wire insect cages, two or three glass jars and Fabre's only microscope of ancient pattern presented to him by the chemist, Dumas. At the farther end is a large fireplace, on the mantel of which stands the earthen tube and the egg of a burrowing beetle, *Geotrupes,* a tube of a cicada with its nymph, and a tube of a mining bee, all as Fabre had mounted them. Around two sides of the room cases are arranged for holding his collections of plants, shells and insects. The main house has a wide hall running through the middle, with the dining-room on the left and the living-room at

THE STEPS LEADING UP TO THE POOL IN HIS HARMAS DIRECTLY IN FRONT OF HIS DOOR.

the right. About the walls of the latter are perhaps a dozen portraits of Fabre taken at different periods and at the farther end stands a large cabinet containing various editions of his "*Souvenirs Entomologiques*" while on the table in the middle of the room reposes the visitors' book containing the names of those who have called to pay homage to the scientist. It was the garden, however, that interested me most, for it was this part of the harmas that constituted the living laboratory of entomology in which so many of Fabre's observations on the behavior of insects were made.

The garden is cut off from the house and the wide way of which we have spoken by the water basins, the low stone wall with its cover of trailing vines, and the row of lilacs on the left border of the road leading to the iron gate. As we enter the garden through



BIRD'S-EYE VIEW OF THE HARMAS,

SHOWING THE HOUSE IN THE CORNER WITH THE WIDE WAY IN FRONT EXTENDING TO THE IRON GATEWAY; THE CIRCULAR POOL AND THE GARDEN WITH ITS TANGLES OF PLANTINGS ACCESSIBLE THROUGH THE WINDING PATHS.

the passageway in the wall we come first upon the fountain and its big circular pool among a thick growth of shrubs and trees through which the sunlight can scarce find an opening. Beyond the pool lies the garden proper in which Fabre planted and nurtured thick masses of the native herbs and shrubs with graveled walks threading their way through them and affording access to all parts of the lovely wilderness. He had simulated nature as far as possible in order to attract the insects he found among the native vegetation. Of the original fauna he says, "Never in my hunting memories have I seen so large a population at a single spot; all trades have made it their rallying-point. Here come hunters of every kind of game, builders in clay, weavers of cotton goods, collectors of pieces cut from a leaf or the petals of a flower, architects in pasteboard, plasterers mixing mortar, carpenters boring wood, miners digging underground galleries, workers handling goldbeater's skin and many more." It was here in the garden that we found a riot of golden broom, wild thyme, rosemary, purple sage, coronilla, honeysuckle, acacia, Judas-tree, lilacs, fig-trees and other wild native plants, many of them in bloom on this April day and flooding the air with their fragrance. The birds were busy with their spring nesting and were singing in the abandon of their joy, for the mistral had spent itself and the soft southern breezes were blowing across the garden, while the mountains, which Fabre loved so much, were of a misty blue in the hazy distance. This was where he made his "observations under the blue sky to the song of the cicada," where he studied "instinct in its loftier manifestations," and where he recorded "the habits, the manner of living, the work, the struggles, the propagation of that little world with which agriculture and philosophy

have most seriously to reckon''; and if he wished to vary his field of observation "the mountain is but a few steps away, with its tangle of arbutus, rock-roses and arborescent heather; with its sandy spaces dear to the Bembeces; with its marly slopes exploited by different wasps and bees. And that is why, foreseeing these riches, I have abandoned the town for the village and come to Sérignan to weed my turnips and water my lettuces.''

The area enclosed within the walls of the harmas constitutes just about a hectare (2.47 acres), a comparatively small field laboratory, yet how productive it has been in the science of entomology. As I wandered along the paths through the garden where Fabre had walked and watched and recorded on many days as wonderful as this April day and beneath the marvelously blue sky of his beloved country I was filled with an overwhelming sense of gratitude to this man for the inspiration of his life, his work and the style with which he clothed his ideas. Of the latter he has been moved to say:

> Others again have reproached me with my style, which has not the solemnity, nay, better, the dryness of the schools. They fear lest a page that is read without fatigue should not always be the expression of the truth. Were I to take their word for it, we are profound only on condition of being obscure. . . . Yes, my pages, though they bristle not with hollow formulas nor learned smatterings, are the exact narrative of facts observed, neither more nor less.

On my return from the garden, Mademoiselle led us into the living room in order that I might sign the visitors' book as the final act in our rite of respect to her father; but before taking final leave I requested the privilege of making a photograph of her to carry back with me to America. She seemed rather overcome with the idea of having her likeness exhibited among strangers so far from her home, but after some urging she shyly consented to stand and face the camera for a moment. The result, unfortunately, was not all I had hoped for, yet the film gave me a record more indelible and lasting than a mental one is likely to be. Much to my surprise and delight, when we finally arose to leave, she walked with us out through the tiny door in the wall and along the path outside of the harmas to the edge of the road; and the last picture I have of this memorable visit is that of the petite, wistful figure of Mademoiselle with her gray hair and wrinkled face standing by the roadside and watching us in an attitude of kindly farewell as we reluctantly started on our way back to the village.

DAVID RITTENHOUSE—PIONEER AMERICAN ASTRONOMER

By Professor W. CARL RUFUS
DETROIT OBSERVATORY

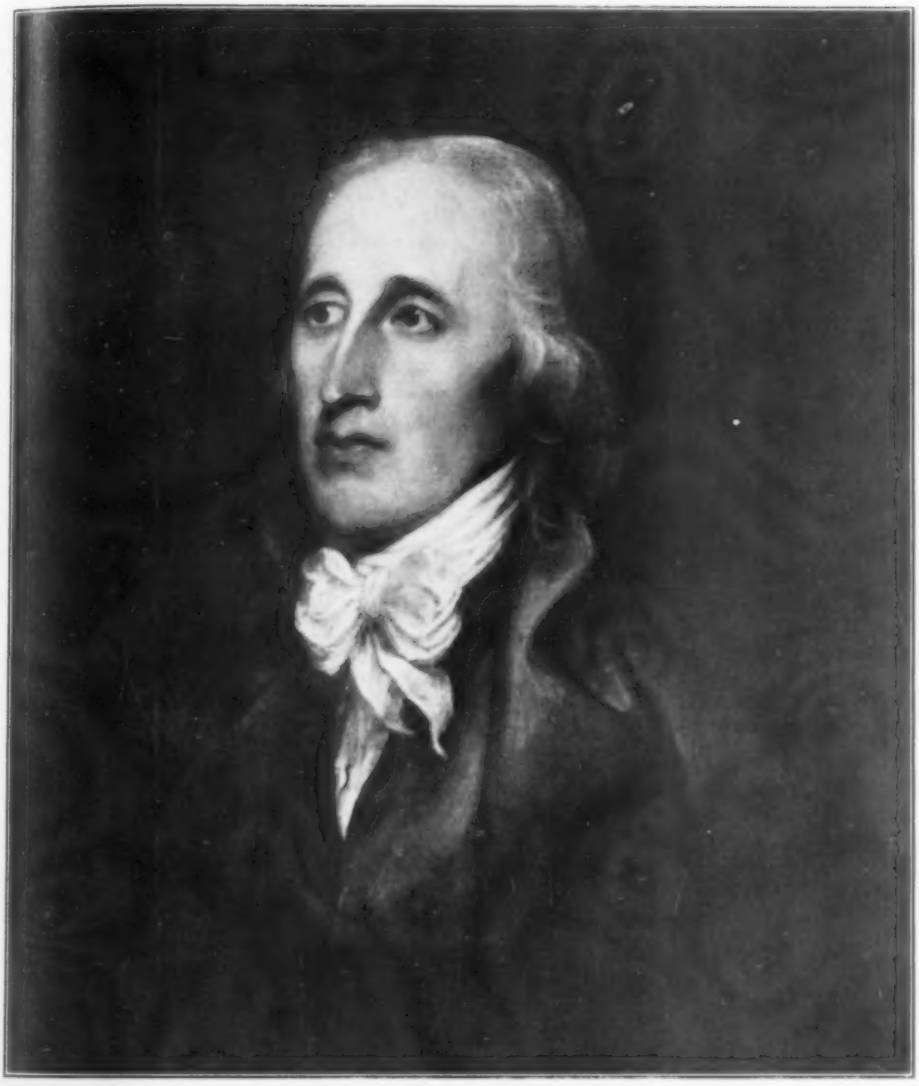
AMERICA's preeminence in astronomy was not gained at a single bound. Pioneers during the colonial period and early days of the republic began the ladder from the lowly earth to the vaulted skies. Foremost among them were Benjamin Franklin, John Winthrop and David Rittenhouse, "the philosophical trio of the Revolution."

The genius of Franklin flashed in many fields like the lightning which he drew from the skies. Printer, author, organizer, scientist, philosopher and statesman, the many-sided Franklin dedicated to America a patriotic career in which the political scarcely outshone the scientific in his day. Original contributions to nineteen sciences are claimed for him, though modern experts dub him an amateur and a dabbler. Bridget, his wife, had little patience with his "rattle-traps used in astronomy." His Junto, 1727, was the precursor of the American Philosophical Society, of which he was the first president.

John Winthrop, of Harvard, led the first scientific expedition of this country to Newfoundland in 1761 to observe the transit of Venus over the sun. Heir to the riches of transplanted European scholarship, his broad culture and scientific research contributed largely to the reputation of Harvard, locally and abroad. His activities included observations of the transits of Venus and Mercury, solar and lunar eclipses, sunspots, meteors, comets, earthquakes, lightning, magnetism and aberration.

David Rittenhouse, son of the soil, was a self-made astronomer, a true product of American genius and toil and the highest embodiment of the pioneer spirit in science during the colonial period. On his farm in Norriton, Pennsylvania, with instruments of his own construction, he made observations of the transit of Venus in 1769 to determine the distance of the sun, which equalled in accuracy those obtained by professional astronomers, including the astronomer royal, fully equipped with the finest instruments of the world.

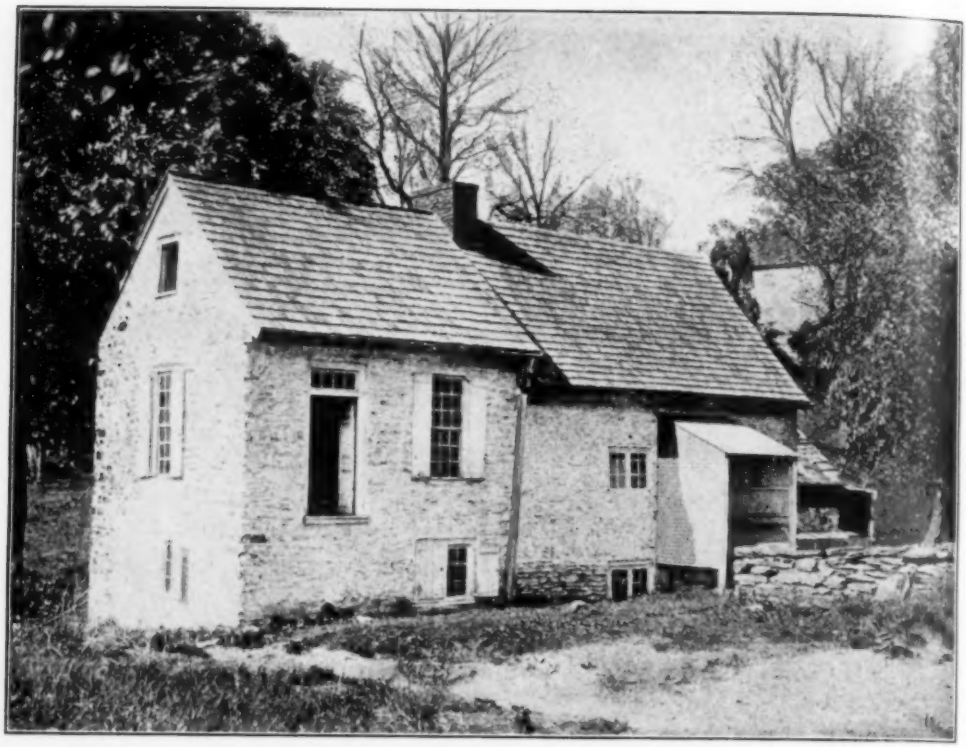
David Rittenhouse was born on April 8, 1732, the year of Washington's birth, at Paper Mill Run, near Germantown, Pennsylvania. His father abandoned paper-making, which was established in this country by his ancestors in 1690, and moved on a farm in Norriton, about twenty miles from Philadelphia. David, the oldest son, third child in a family of ten, at an early age was destined for farm work. His mechanical ability attracted attention by his boyhood productions, including a miniature waterwheel. This talent received encouragement at twelve, when he inherited a chest of carpenter's tools and mathematical books from his maternal uncle. No schooling beyond the three R's was available, but he assimilated all the books he could procure, showing special fondness for mathematics and astronomy and covering plow-handles, fences, stones and barn doors with figures and constellations. At seventeen he made a wooden clock, followed by a metallic timekeeper. His father reluctantly let him quit the plow, and at nineteen he opened a shop on the farm for clock-making, where he worked and studied assiduously, seri-



—*By Trumbull.* (*Loaned through the courtesy of the Pennsylvania Academy of Art.*)
DAVID RITTENHOUSE

ously impairing his health. He resorted to Yellow Springs for his health, but returned with a permanent pain in his breast.

Here alone he is said to have mastered Newton's "Principia" in the English translation of Mr. Motte. This classic contains the greatest contributions to science ever produced by one individual. The fundamental laws of motion, mass, force and acceleration were clearly demonstrated. Fluxions, a geometrical form of the infinitesimal calculus, were invented and used in astronomical problems. The law of gravitation, the greatest scientific generalization of the human mind at that time, if not for all time, was the crowning feature. The youthful



—*Courtesy of Popular Astronomy*

THE BIRTHPLACE OF DAVID RITTENHOUSE

genius recognized the superlative value of the masterpiece.

At this time, as frequently happens to developing genius, a fortunate incident occurred. Thomas Barton, an Episcopal clergyman educated at Dublin, came to America, taught in the Rittenhouse neighborhood, fell in love with David and married his sister, Esther. He was able to provide books and help direct the study of his protégé. Latin and Greek were attacked; the "Principia" was devoured in the original.

We next find Rittenhouse making a telescope. He wrote to Barton, who had moved to Philadelphia:

> I am spending my time in the old trifling manner, and am so taken with optics, that I do not know whether, if the enemy should invade this part of the country, as Archimedes was slain while making geometrical figures in the sand, so I should die making a telescope.

It is said that he constructed the first telescope made in America.

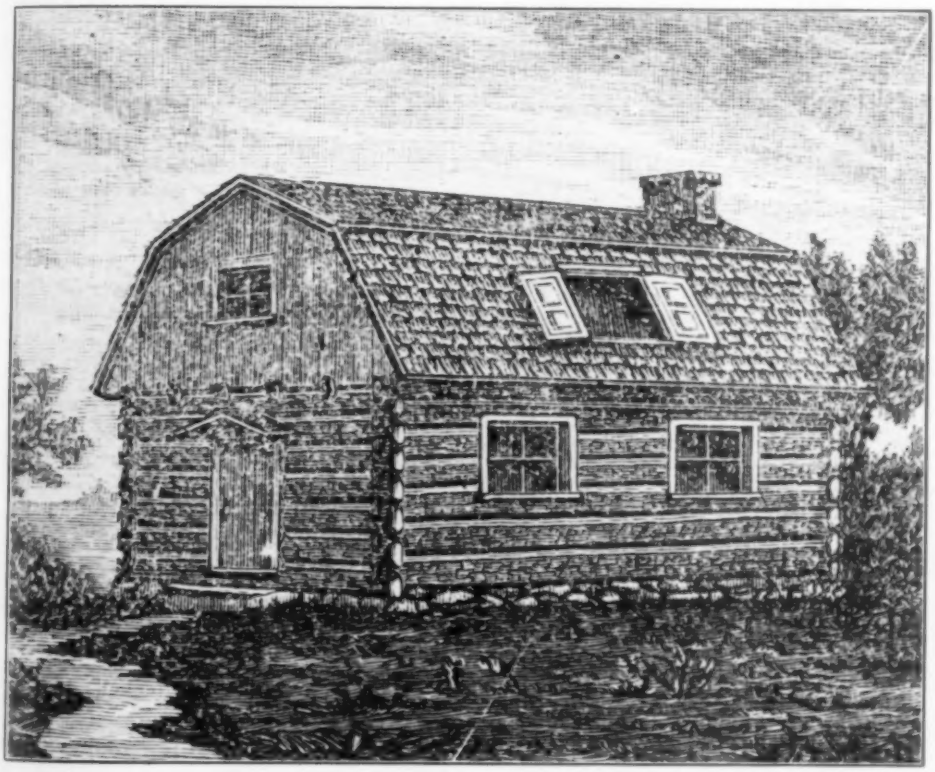
Through the influence of Barton his ability and skill were heralded in Philadelphia. Mr. Penn, proprietor of the province, engaged him in 1763 to "fix the circle about Newcastle" to settle a boundary dispute with Lord Baltimore. So accurate was the survey that Mason and Dixon, experts from England trained at the royal observatory, incorporated his work in their famous Dixie line. Later he settled numerous disputes involving Pennsylvania, Delaware, Maryland, Virginia, New York, New Jersey and Massachusetts. Part of his time was spent in making the instruments used.

In 1766 he married Eleanor Colston, a Quakeress, daughter of a neighboring farmer. Continuing the "old trifling

manner" of spending his time, he experimented on the compressibility of water, invented a metallic thermometer credited to Breguet in the nineteenth century, noted the effect of temperature on clock-rate and devised two kinds of compensating pendulums. He wrote a paper on the problem of Archimedes, concluding that without a lever a weight of 200 pounds applied for 105 years is sufficient to move the earth one inch. In 1767 the College of Philadelphia decorated him Master of Arts for "extraordinary progress and improvement made by a felicity of natural genius, in mechanics, mathematics, astronomy and other liberal arts and sciences, adorned by singular modesty and irreproachable morals." During the next three years two events chiefly engaged his attention, the construction of a celebrated orrery and the observation of the transit of Venus in 1769.

His first orrery, begun in 1767, was a complicated mechanism designed to illustrate the motions of the heavenly bodies. The problem of their motion had occupied the world's greatest thinkers for two thousand years. Plato set it for his disciples; Newton completed its solution by the application of his law of gravitation. Archimedes made a model to represent these motions; others had constructed larger and more intricate machines; but Rittenhouse proposed to transcend them all. He says:

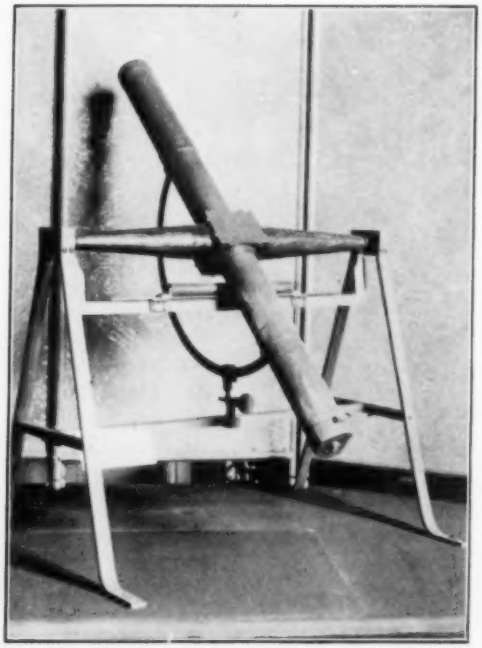
> I did not design a Machine, which should give the ignorant in astronomy a just view of



—Courtesy of Popular Astronomy

RITTENHOUSE OBSERVATORY

THE FIRST OBSERVATORY BUILT IN THE UNITED STATES.



THE FIRST KNOWN TELESCOPE CONSTRUCTED IN THE UNITED STATES, WAS MADE AND USED BY DAVID RITTENHOUSE. IT IS NOW ON EXHIBITION IN THE VERY ROOM IN WHICH RITTENHOUSE PRESIDED OVER THE MEETINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY.

the Solar System; but rather astonish the skilful and curious examiner, by a most accurate correspondence between the situations and motions of our little representatives of the heavenly bodies, and the situations and motions of these bodies, themselves. I would have my Orrery really useful, by making it capable of informing us, truly, of the astronomical phenomena for any particular point of time; which, I do not find that any Orrery yet made, can do.

Here was an ambitious task! It required the accurate knowledge of the professional astronomer regarding the orbits of the planets and satellites and the technical skill of the trained mechanician to design and construct the combinations of wheels to guide the brass and ivory balls at their proper speeds, inclinations, nodes and eccentricities. All was to be driven by a pendulum clock contrived to play a variety of music. The main face was four feet square, of polished brass, silvered and painted and otherwise ornamented. In front moved the miniature planets around the sun with an accuracy sufficient to represent their positions for five thousand years. Two lesser faces were four feet by two feet three inches. One represented Jupiter and its satellites, their eclipses and transits; also Saturn with its ring and attendants. The other illustrated lunar and solar eclipses, including an optical device for exhibiting their appearance at any place on the earth.

A description of the orrery, communicated by Dr. Smith, provost of the College of Philadelphia, occupies first place in the first volume of the American Philosophical Society. Such was its fame in its day. Thomas Jefferson said of its maker, "He has not indeed made a world; but he has by imitation approached nearer its Maker than any man who has lived from the creation to this day." Princeton secured its possession, to the great chagrin of Dr. Smith. A second was made for Philadelphia. Negotiations for others followed. A trip to England for its exhibition was considered, but other events interfered including the transit of Venus, which had delayed its completion.

Transits of Venus occur in pairs eight years apart at intervals of more than a century: 1761 and 1769, 1874 and 1882; the next will be 2004 and 2012. Winthrop's trip in 1761 was mentioned; but no costly expedition for colonial astronomers in 1769 was necessary; the phenomenon came to their very windows. Rittenhouse's "Projection of the Transit" was laid before the American Philosophical Society. John Ewing presented one for Philadelphia. Three committees were appointed and three observing sites were selected, the State House Square in Philadelphia, the farm of Rittenhouse, and a station near Cape

Henlopen. Rittenhouse erected an observatory, designed not merely for this purpose, but for permanent use, the first built in this country.

The society lacked funds, and instruments were expensive. Politics helped to equip the State House station. It was "provided with an excellent sector of 6 feet radius, made by the accurate Mr. Bird, and an equal altitude and transit instrument, both belonging to the honourable Proprietaries of this province, which the Governor very generously lent to the society on this occasion." Telescopes and additional equipment for the State House Square were obtained from England. The farm did not fare as well. A Gregorian reflector with a Dolland micrometer was ordered from London to be used by Dr. Smith. With it came lenses for a refracting telescope for Harvard. Arriving too late to be forwarded before the great event, they were impressed into service, fitted together by Rittenhouse and used by Mr. Lukens. We hesitate to imagine the reactions of Winthrop, of Harvard.

Rittenhouse was left to his own resources. In preparation he made an equal altitude instrument, a transit telescope and an excellent timepiece, upon which depended the accuracy of the observations. He spent several months determining the latitude and longitude of the observatory, rating the clocks and making preliminary computations. Dr. Smith reported:

> Our other engagements did not permit Mr. Lukens or myself to pay much attention to the necessary preparations; but we knew that we had entrusted them to a gentleman on the spot, who had joined to a complete skill in mechanics, so extensive an astronomical and mathematical knowledge, that the use, management, and even the construction of the necessary apparatus, were perfectly familiar to him.

The success of the observations was due to Rittenhouse. Maskelyne, the astronomer royal of England, acknowledging their receipt from the Honorable Thomas Penn, says, "I thank you for the account of the Pennsylvania observations, which seem excellent and complete, and do honor to the gentlemen who made them." Rittenhouse immediately began the reductions. Data by the Norriton station combined with Greenwich observations gave the most accurate value of the sun's distance, 92,940,000 miles, in striking agreement with the present adopted value, 92,900,000.

Rittenhouse also observed an atmosphere of Venus, a phenomenon which escaped the astronomer royal. Other astronomical activity of Rittenhouse during this period included a transit of Mercury, November 9, 1769, a survey between the observatories of Norriton and Philadelphia, observations of Lexell's comet, 1770, and the determination of its orbit, "the fruit of three or four days labor." A paper on "An Easy Method of Deducing the Time of the Sun's Passing the Meridian" attracted the favorable attention of VonZach.

Fame was able to accomplish what patronage could not do. Rittenhouse was induced to move to Philadelphia in the fall of 1770. In December he suffered the loss of his wife, a severe blow to his sensitive nature. "Now, neither money nor reputation has any charms," he wrote to Barton. Work on his orreries and their explanation to crowds became irksome. The American Philosophical Society elected him as one of its secretaries; the Pennsylvania Assembly granted him an honorarium of three hundred pounds and bargained for a third orrery with a face eight feet square. Rittenhouse went so far afield as to prepare a paper, "Relating to Birds being Charmed by Snakes" and to carry on some experiments with Kinnersley on the electrical properties of the eel. In 1772 he was painted by Peale, honored by Princeton with the degree of master of arts, gave up a con-

templated visit to Europe and married Hannah Jacobs.

Commissions and offices were thrust upon him, some petty, others important. He served committees to examine specimens of flint glass, to tend rain-gauges, to examine the first steam-engine in this country, "which did not continue its motion long." He assumed charge of the State House clock, conducted boundary, canal and river surveys, became curator and librarian of the American Philosophical Society and delivered its annual oration on astronomy. He was about to become public astronomer with an observatory to be provided by the legislature, when suddenly the guns of Lexington and Concord were heard around the world.

Then followed the call to arms. Rittenhouse responded as engineer of the committee of safety for Philadelphia. To obtain lead for bullets he substituted iron for lead clock-weights throughout the city. He was called upon to arrange for casting cannon, to superintend the manufacture of saltpeter, to select a site for a powder-mill, to locate a magazine for military stores, to experiment on rifling cannon and musket balls and to devise chain protection for the harbors. He became vice-president of the committee of safety and president of the new council of safety, military executive of the state, which possessed unlimited capital power. At the approach of the enemy he issued an exhortation:

> We therefore entreat you by the most sacred of all bonds, the love of virtue, of liberty, of your country, to forget every distinction, and unite as one man in this time of extreme danger. Let us defend ourselves like men determined to be free.

As state treasurer he accompanied the removal of the capital to Lancaster. One week after the evacuation of Philadelphia by the British, Rittenhouse, Smith and Lukens returned to their telescopes to observe a solar eclipse, June 24, 1778. A pitiful effort had been made to maintain observations, including a transit of Mercury, November 2, 1776, and a solar eclipse January 9, 1777. Rittenhouse had also written a "Defense of the Newtonian System" in 1776 and in Lancaster prepared astronomical data for Father Abraham's Pocket Almanac.

The conflict between the demands of war and science was acute. The Declaration of Independence was proclaimed in Philadelphia from the platform of the transit observatory in State House Square. During the British occupation General Howe issued an order protecting the orrery of Rittenhouse. The one at Princeton suffered the loss of wheels and balls which adorned the watch-chains of colonial troops. Jefferson remonstrated against the transfer of the service of Rittenhouse from astronomy to politics. "Nobody," he said, "can conceive that nature ever intended to throw away a Newton upon the occupation of a crown." A well-meaning poet advised Rittenhouse:

> Meddle not with state affairs,
> Keep acquaintance with the stars.

Like Franklin, Washington, Jefferson and others, he responded unreservedly to the call of duty. He served on the Constitutional Convention of Pennsylvania and the General Assembly. He was state treasurer, trustee of the loan fund and member of the board of war. He was professor of astronomy in the College of Philadelphia, served on its board of trustees and filled the office of vice-provost. He was one of the commissioners to organize the United States bank and was the first director of the mint appointed by Washington.

But astronomy was his first love. In 1781, before the smoke of battle had cleared away, the assembly granted him 250 pounds for an observatory in Phila-

delphia. This he erected before providing a residence for himself and family. It was the only one in America recognized by the French astronomer, Lalande. To determine the meridian to adjust his instruments, when buildings interfered, he invented the collimating telescope, a substitute for a distant azimuth mark. This invention alone, so useful in practical astronomy, would assure its discoverer a permanent place in the history of astronomy. He also discovered the use of spider threads in the eyepiece of a transit; but this was anticipated by an Italian astronomer, Fontana.

When the American Philosophical Society resumed publication after the war, the contributions of Rittenhouse again formed an important part. These contained observations on the sun, moon, Mercury and the newly discovered planet, Uranus, on comets, including one discovered by himself, on a remarkable meteor and on the effects of lightning. He anticipated Brewster in explaining the apparent conversion of cameos into intaglios and *vice versa*, and solved an optical problem proposed by Professor Hopkinson. He conducted experiments on magnetism, the improvement of timepieces and the expansion of wood by heat. He invented a wooden hygrometer for measuring atmospheric moisture. His mathematical work included a method of finding the sum of several powers of the sines, another to determine the true place of a planet in an elliptical orbit, and a method of raising the common logarithm of any number immediately. Degrees were conferred upon him by American colleges; he was elected president of the American Philosophical Society and a foreign member of the Royal Society of London, the highest possible scientific honor of his day.

His lifelong association with Franklin resulted in mutual admiration and respect. He was one of the pallbearers of Franklin, whose will contained this item, "My reflecting telescope, I give to my friend, Mr. David Rittenhouse, for the use of his observatory." His friendship with Washington was also intimate. A painting of Rittenhouse hangs on the walls of Mt. Vernon. He made repairs and adjustments on Washington's surveying instruments, such as the theodolite. He made and presented a pair of spectacles to Washington, who donned them in public for the first time before his assembled soldiers with the pleasantry: "I have grown gray in your service, and now find myself growing blind."

Rittenhouse, too, was growing old and feeble. The troublesome pain had chiselled its way into the delicate, sensitive features. Peale, in his later paintings, only half conceals it. Trumbull caught the superfine spirit underneath. Rittenhouse mourned that he could not spend more time at his telescope. But the observatory claimed him at last. The end came rather suddenly; an attack of cholera, the doctor, the unsuccessful leech, the will and rest beneath the observatory.

They came to do him honor—Washington and his cabinet, congressmen, justices, foreign ministers, state officials and members of the learned societies. In their presence Dr. Benjamin Rush delivered "an eloquent, learned, comprehensive and just eulogium." Jefferson, succeeding to the office of president of the American Philosophical Society, paid this fitting tribute: "Genius, science, modesty, purity of morals, simplicity of manners, marked him as one of nature's best samples of the perfection she can cover under the human form." And to-day we add our token in memory of David Rittenhouse, America's peerless pioneer astronomer.

VISIONS AND DREAMS OF A SCIENTIFIC MAN[1]

By Dr. PAUL R. HEYL

BUREAU OF STANDARDS

VISIONS and dreams? Who is this speaking? A scientific man, you say? And pray what business has a scientific man with anything so beautiful, so fragile? Is not science matter-of-fact, gray and prosaic? And are not scientific men likewise, as every one knows? Visions and dreams of a scientific man, forsooth! What manner of dreams may these be? Fancy in a strait-jacket, for melody a monotone; but as for beauty —ah, how can that be?

Visions and dreams—man's most precious possessions! Was it not the greatest blessing which the prophet Joel could pronounce upon ancient Israel, "Your young men shall see visions, and your old men shall dream dreams"? But and if common opinion be true, then are we scientists of all men most miserable, for without dreams and phantasms can not a man live.

But common opinion is wrong in this matter. We scientific men have our share—ay, more than our share of these great gifts; the measure meted out to us is heaped up, pressed down and running over. And the visions and dreams of a scientific man are in no degree inferior to those of the mystic or the poet in grandeur or wonder, while they possess in addition a distinctive feature —a vitalizing element of reality.

Reality? What is real? We are not quite so sure of the answer to that question as we were thirty years ago, for the twentieth century has sadly turned our ideas upside down; matter itself has become a form of energy. The realities of to-day were the intangibles of the past generation; but intangible and immaterial as they may be they are none the less real.

Consider the compass needle quivering on its pivot. Hold a magnet toward it; see how it turns and points to the magnet, and how its quivering becomes more rapid. Bring the magnet nearer; the needle becomes still more excited. Does it not suggest a dog with wagging tail at the sight of food held out to him? He points always toward the food as we move it here and there, and the nearer we bring the food the more rapidly wags the tail. We can explain the phenomena exhibited by the dog, at least to our own satisfaction, for the dog can see the food; but what of the compass needle? Interpose a board between it and the magnet; the excitement is not one whit the less. What strange connection is there between the needle and the magnet? It is real, real as anything we know; witness its results; yet we can neither see nor feel it. And as we study this mystery and ponder over the reality of the intangible and the immaterial there wells up in us an emotion akin to that of that ancient mystic who, in the face of a great wonder, put his shoes off from his feet, for he felt that he stood on holy ground. Truly, the things that are seen are temporal, but the things that are not seen are eternal.

In the everyday work of a scientific man he is continually brought into contact at first hand with that which is wonderful and mysterious, and yet real. The simplest and most commonplace natural phenomenon, even the falling of a stone to earth, is wonderful past all speaking. This truth is for the most part obscured by familiarity. It is our task, as students and teachers of science, to brush away this dust of familiarity

[1] Publication approved by the director of the Bureau of Standards of the U. S. Department of Commerce.

and uncover the wonder and the mystery of that which lies below. And if, again, like Moses of old, we feel that we are slow of speech, let us call upon our blood-brothers the poets to speak in our stead; for the poets (may their tribe increase!) know well that science has its poetic side, and that scientific men also have their visions and dreams. They understand; and how beautifully they have expressed it for us! What does Longfellow say in his "Lines on the Fiftieth Birthday of Agassiz":

And Nature, the old Nurse, took
The child upon her knee,
Saying: "Here is a story book
Thy Father hath written for thee.

"Come, wander with me," she said,
Into regions yet untrod,
And read what is still unread
In the manuscripts of God."

And he wandered away and away
With Nature, the dear old Nurse,
Who sang to him, night and day,
The rhymes of the Universe.

And if ever the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvellous tale.

Song and story, vision and dream—who can resist them? From old times these have been the surest way to the heart and the understanding of man. Nature's music is as potent as that of the Pied Piper; her tales lose no jot of interest because they are true. Truth is not only stranger but stronger than fiction. Men have died for truth, ay, even for that which they had been merely told was truth; and he who has once learned the language which Nature speaks asks for nothing better henceforth than to be her willing slave and devoted disciple.

And wherein lies this potency of Nature's appeal? What is the scientific man's reward for a lifetime of devotion? Very much the same as the reward of those who of old ate of the fruit of the tree of knowledge: their eyes were opened.

It is said that a lady once remarked to the artist Turner that she could not see in a real sunset the tints that he put into his paintings. "Madam," replied the artist, "do you not wish you could?" The scientific man pities him who walks unseeing and unknowing through the wonderland about him. To such a one is life truly gray, dusty, sordid and prosaic, not to the student of Nature.

The poet sees far, but the scientific man sees farther. When the aurora spreads its shifting tangle of white, green or purple across the northern sky your really prosaic person (whose name is legion) may be momentarily attracted by its beauty, but scarcely more than by the sheen of silk over a shop counter. The poet is more deeply moved, and speaks forth his fancy:

Upon the sky are blazoned forth
The silent fires of the North.

How rich the far horizon's glow!
What noble city lies below?

Methinks those gleams of pearly light
Reflections are from portals white;

That living green, from pastures blest,
Where weary souls for aye may rest.

And lo! 'mid other tints outpoured,
The royal purple of the Lord!

But the scientific man, as he looks at this flickering play of color, is conscious of a rush of visions through his mind, crowding upon one another. His thoughts go back to the sun, that great benefactor of our race, who besides feeding and warming us sets forth for our entertainment this gorgeous color symphony. He sees a storm arising suddenly in the solar atmosphere, some whirlwind great enough to engulf the earth, and toss it like a ball in a fountain; some "steep down gulf of liquid fire" (in Othello's phrase) which by magic transcending the swiftness of

Puck transmits its effect over millions of miles to the earth and excites this brilliant display for our wonder and admiration. And he sees more. He sees the compass needle forsaking its steadfast allegiance to the north in the vain attempt to follow this will-o'-the-wisp of the sky. He sees ships off their course unknowingly, perhaps dangerously. He sees disordered telegraph lines, anxious railroad officials, delayed trains and annoyed passengers, and there is borne in upon him an overwhelming sense of our utter dependence upon the sun, and of the bonds, intangible and immaterial, yet potent and masterful, by which the sun rules and sways his planetary family like some ancient patriarch whose word was life or death when he chose to speak it. He sees himself and his fellows as subjects or courtiers of this mighty sun-monarch, dependent upon his favor and his bounty for their very existence, and sensitive to the slightest change in his royal mood; and he reflects that, unlike mortal rulers, no flattery, supplication, gift or prayer can move by the slightest this monarch from his impersonal indifference, for he shineth on the evil and on the good, and sendeth rain on the just and on the unjust.

A word, to the scientific man, may be sufficient to call up a multitude of visions. Speak of time to the average person; it may connote to him the idea of something to be killed, to be gotten through with as pleasantly as possible; or to another something so filled with duties that he has no opportunity to think about it. To the scientific man it may suggest a portion of a thread that lies in his hand, which he may follow far back into the mists of antiquity, and see as he goes that most majestic of Nature's visions, the pageant of time.

Go back with the historian a few thousand years, until written records fail; then let the anthropologist lead you into the dark caves of the Pyrenees, and show you those wondrous wall paintings—older than Egypt, older than Babylon. Then stand with the geologist as he examines the fossil record of life on earth, millions of years before the advent of man; and when the geologist must stop for lack of material, study with the astronomer the genesis of our earth, of our solar system, as far as we can learn it by a study of the heavens.

What a vision have we here! What a pageant is spread before us as we follow back along the thread of time! At its beginning lies the sun, shining as now, but in lonely splendor, for no planetary system accompanies him. But see that other distant sun approaching! Will there be a collision? No; they will pass each other, and at a safe distance; but as they approach see how each sun, at the bidding of gravitation, raises a great tidal wave in the other. But the distance is too great to be spanned by these friendly efforts; a brief moment of closest approach, a supreme struggle to reach the other—and the outstretched arm of our sun snaps off, and breaks up like a water jet into a crowd of particles, large and small.

The visiting sun passes on his endless way; the pull of gravitation subsides, and our sun resumes his normal shape. But now he is no longer alone; the crowd of particles circles round him, gradually condensing into aggregates here and there, until it finally takes the shape of our planetary system, still retaining traces of its genesis in the asteroids and in the rings of Saturn.

And what of the other sun? Has he carried away with him a souvenir of his visit in the shape of a planetary system of his own? Perhaps; though if he were many times as massive as our sun he might have been able to retain his own mass while disrupting that of another.

A rare vision this, indeed; for so widely separated are the stars of heaven that such an encounter can not be expected to happen oftener than once in an eon. A planetary system such as ours must be an unusual thing in the uni-

verse; perhaps there may be but one other like it.

How profoundly a vision of this nature may influence our dreams! Who has not gazed at the starry heavens and speculated on the possibility of each of those distant suns possessing a planetary retinue? And it would be strange indeed if among those millions of planets there would not be at least a few hundreds in condition to maintain life. But how changed is our outlook! How infrequent a thing is a suitable setting for life; how rare and precious is that gift of life which we enjoy and in what low esteem do we often hold it!

But while we are philosophizing the pageant is passing. Look again—at the earth now. Its surface has cooled; land and water are to be seen there; but what a land it is! Barren rock, sand and gravel, desolate and forbidding, unrelieved by a single green blade or patch of soft brown earth. A desert prospect; yet strangely enough there is water in plenty—lakes of it, oceans of it! What curse lies on this land that it holds no living thing?

But look—there in that sheltered nook, where the water lies still—see that patch of green scum on the surface, and in the water a little slimy jelly here and there. Trifles? Ay, trifles as yet, but most wonderful, for in them lie the promise and potency of things incredible, which yet shall be; of grass, herb and tree which shall clothe the earth in green raiment; of fish and flying dragons; of mammoth, cave bear and saber-toothed tiger; and of man.

Feeble must have been life's first beginnings; many incipient sparks of life must have flickered fruitlessly out; but chance and a kindlier environment preserved others, and the flame grew, slowly at first, but with ever-increasing rapidity. And with the advent of man upon the scene the interest of the pageant for human observers becomes intense. This latter portion of the great drama of Nature may lack the grandeur of the first act, where the actors were suns, but what it lacks in mighty outline it makes up in a wealth of intricate detail.

Once there was a man favored of the gods, for he saw this act of the drama—saw it in a day dream which he was fortunately able to preserve before it faded away. It is long since this happened, before some of those who read these lines had discovered America,[2] and allowance must be made for theories now discarded, such as that the glacial period was caused by a change in the shape of the earth's orbit. But the pageant passes—let us look at this dream of a scientific man.

The Destroying Angel hovered near the earth. It was millions of years since he had last passed this way; space is large and his duties many. When the Destroyer had last seen the earth it had been a liquid, white-hot globe, just beginning to solidify, but now its crust had cooled greatly. Land and water divided the earth's surface between them, and on the land there were little creeping things.

"Ay," said the Destroyer, "It is time that I returned. Your time has come, ye maggots. I have seen your like before, on other balls, and I have done my duty."

Now the Destroyer was cunning and resourceful and cruel, so instead of crushing the creeping things he put forth his hand and gently pushed the rushing ball slightly out of its circular path. Round and round the sun it sped in an ever-lengthening ellipse, and with each year's circuit the winters grew longer and colder and the summers shorter. A great sheet of snow and ice began to grow about the North Pole, gradually covering the surface of the earth, and driving the creeping things southward before it, so that many of them perished from the cold. And the Destroyer left the creeping things to their fate, and flew onward, laughing.

2 "The Destroyer" appeared in *Lippincott's Magazine* November, 1898.

But the push had not been great, and by the time the ice sheet had reached half way to the equator the elliptical path ceased to lengthen, and began gradually to reassume a circular form. And so it was, after some hundreds of thousands of years, when the Destroyer again passed that way, he found the earth's path again nearly circular, and the creeping things more numerous than before. The Destroyer's brow darkened, and he said: "This time shall ye all surely die!" But as he drew near to crush them he stayed his hand, for he saw strange sights, the like of which his eyes had never seen before. Tiny sparks glowed here and there; some of the creatures traversed the waters on floating things. On land, caravans were passing from spot to spot where the creatures were most thickly gathered. The Destroyer drew nearer and examined with interest. Here several of the creatures were gathered around one of the sparks beating something vigorously—clink! clink! Others were making long straight scratches in the soil with a crooked thing. But most wonderful of all, some were making black marks on sheets of white material, and others were gazing intently at similarly marked pieces.

The Destroyer withdrew his hand, saying: "Let be; let us see what will come of this wonder. Yet they shall know that I am the master, and that I can destroy them at what time I will." So saying, he stooped and breathed gently on a cluster of the creeping things. And so it was that when the creeping things felt the breath of the Destroyer they uttered piping little cries and drew shining things from their sides, and rushing forth to a neighboring spot slew many of the creatures there. Then came others to the rescue of those that were attacked, and still others to the support of those attacking until the fourth part of the world was at war. And again the Destroyer laughed as he flew away.

But a few thousand years after that the Destroyer again returned, and found the creeping things more numerous than before. Again he stooped and breathed upon a spot where the creatures were most thickly gathered; but now only a few drew their shining things, while from all the rest went up a hissing sound: "Sh—sh—sh—" until those who had drawn their shining things put them up again. And the Destroyer wondered greatly at the failure of this magic, but, being full of resource, he strewed seeds of pestilence among the creatures, so that many of them sickened and died. And there went up a wailing noise, and those that were left gathered together the bodies of the dead and dug great holes wherein they buried them by the hundreds. And again the Destroyer laughed as he sped onward.

But a hundred years after that the Destroyer returned and found the creatures more numerous than ever. They swarmed together in great clusters, where they did many marvelous things. Here one floated in the air, hanging to a little inflated bag, until the bag burst, and he fell to the ground and perished. At another place there was a great tube pointed upward, with a little creature looking through it. Again the Destroyer strewed seeds of pestilence among them, and waited with a cruel smile; but this time the seeds took no effect. Then was the Destroyer angered, and he said: "What, ye puny ones! Are ye mightier than I?" And stooping low, he blew a great wind upon the earth, so that many of the creeping things were swept to destruction. And when he rose he was red and panting, for it had taken much of his strength; so he flew away, but this time he laughed not.

In this vision there is clearly to be recognized a quality which we find often present in the visions of scientific men—a vein of tragedy. The beautiful aurora can not occur without bringing with it a measure of inconvenience and danger; and even the magnificent spectacle of

the starry heavens is not without its tragic element.

Of the vast collection of astronomical photographs at the Harvard Observatory only a fraction has as yet been examined; but the examination has gone far enough to bring out some rather startling facts concerning those bodies known as new stars or novas which appear every now and then. All of us have heard or read of them; some of us may have seen that brilliant one which appeared in Perseus over twenty-five years ago or that other which was visible about seventeen years later. A star previously unnoticed, of telescopic magnitude only, blazes up within a few hours to a brilliance perhaps exceeding Sirius or equal to Venus at her greatest brightness. Then it slowly fades away. Within the last thirty years one or two occurrences of this kind have happened with attendant phenomena which give us an idea of what may have taken place. The star, moving rapidly through space, as all stars do, including our sun, may have encountered something; perhaps one of those patches of dark nebulous matter with which space is strewn here and there, as dangerous as icebergs on steamship lines of travel.

Many of these dark patches can be recognized by their edges, sharply defined against the starry background surrounding them. If a star happens to plow its way through such a patch of material there will be temporarily a great increase in its surface temperature and a consequent disturbance of the star's internal economy, resulting possibly in an explosion. We are not clear as to just what happens, but from whatever cause the records of the Harvard Observatory show that it happens a good deal oftener than we have ever thought or like to think about. While it is not a matter of daily occurrence it does happen about once in every three weeks; fifteen times a year there is a nova of at least telescopic magnitude; fifteen hundred such occurrences in a century.

We do not need to go farther back than the period of recorded human history to reach a number of such catastrophes as great as the total number of visible stars. The conclusion, as stated by Professor Russell, is that on the average every star in the heavens must suffer this fate more than once in its lifetime!

Now life has been on this earth for at least a million centuries, and in that time there must have been a staggering number of such calamities; yet our sun has escaped. Did he suffer this fate before life appeared on the earth, or is his turn yet to come?

We do not know. There is nothing in sight to excite alarm. Our sun seems to be moving through an unusually dust-free region of space. Is it permissible for a scientific man to dream that the way has been swept for him?

The mind can not avoid speculating on what might have happened if only one of the many stars which have suffered this fate had a planetary retinue in attendance. What if there had been life on one of those planets?

It might have been. It may be happening somewhere at this moment, and the light-borne news may not reach us for a hundred years. Nature is icily indifferent to such a circumstance. It is of no moment whatever to her that there may be a planet attached to that sun which suffers his baptism of fire. There might even have been on such a planet sentient beings who lived and loved and liked life well, as we do. Perhaps some of them even "heard the glorious organ fill transept, loft and nave," and chanted exultingly: "In Thee have I trusted; let me never be confounded!"

Nature's visions are not all of green pastures and still waters. She does not always appear as the kindly old nurse with the story book. At times her aspect is that of a Gorgon, upon whom no man

can look and preserve his soul alive. He who aspires to be numbered among her disciples must be no weakling. He must feel the overmastering passion for truth, be the consequences to his philosophy what they may; truth above all things, even though (as Huxley says) "it sears the eyeballs." He must face the facts unflinchingly, and find the sanest, healthiest way of regarding them; and he must always remember that by his mental attitude, by his reaction to these visions, by the color which they impart to his philosophy, the great mass of unscientific people will judge of science itself, and approve or condemn it. *"Noblesse oblige."* We must set a good example.

This element of tragedy is but seldom found in the dreams of the mystic, who usually ignores or is ignorant of this aspect of Nature, and looks preferably on her more pleasant and subtly intoxicating side. It is perhaps more often found in the visions of the poet, though generally speaking the philosophy of the poet is, "It is so beautiful that it must be true." But the devoted student of Nature says: "It is so true that we must e'en forgive if it be not beautiful."

Such are the visions and dreams of a scientific man; beautiful at times beyond compare, wonderful and mysterious always, and often tinged with tragedy. This is what Nature has to offer her disciples, bitter and sweet together, as is life itself; and just as we find life worth living (else we would not be here to say it) so the student of Nature follows where she leads him, through fair and foul, up hill and down, by green pastures and through the valley of the shadow. Who knows most, fears least; and of the student of Nature, above all men else, it may most truly be said that he has eaten of the fruit of the tree of knowledge; that his eyes are opened; and that he is become as the gods, knowing the good and the evil.

Apart from the heaving, restless world
There lies the Land of Souls.
It hears no sound from the world around
As afar its tumult rolls.

The wall of the land has portals twain,
All beautiful to see.
The gate of life is of pearly grain
And Death is of ebony.

Sometimes the ebon gates swing wide,
And then a soul comes in,
All sore from strife in a long, long life,
And bruised and stained with sin.

Then virgin souls look pitying on,
And wonder what life may be,
And whether 'tis worth the pains of earth
To taste its mystery.

And once the gates of pearl fell back,
And a solemn voice was heard:
"Wilt thou have life, and test its strife?"
But not a virgin stirred.

Beyond the gate was darkness all;
Nothing might one descry.
Each shook the head in awful dread,
For each one feared to try.

Then forth there stepped a deep scarred soul,
Weary and sore and lame.
Not long before had it entered the door
Of Death, with the ebon frame.

About it still was the smell of life,
And still its breath came fast;
Yet through the gates where the darkness waits
It willingly, eagerly passed.

"Wilt thou have life?" Ay, give me life,
Bitter and sweet, O Lord!
Let me but sup another cup
Of thy precious gift outpoured!

Let virgin souls, afraid to pass,
Tremble before the door.
Lo, I have lived and drained my glass,
And fain would drink once more!

OPPORTUNITIES FOR RESEARCH IN MAMMALIAN GENETICS[1]

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I

For centuries man has been actively interested in observing, recording and interpreting the phenomena of heredity. Occasionally among the great mass of workers there have been individuals whose achievements have stood out in bold outlines differentiating them from their contemporaries, from those who had gone before, and from those who were to come. It will be necessary only to mention a few of the most distinguished of these to show the almost unbelievable development of our knowledge of genetics.

At the end of the nineteenth century scientists had accepted Darwin's demonstration of over-production, the existence of variation, natural selection, the elimination of the relatively unfit and the consequent survival of those better fitted to meet required conditions. At the same time many zoologists had begun to think in terms of soma and of germplasm, and had at least gone part way along the road of Weismann's theory of descent. Bateson's "Materials for the Study of Variation" had provided an excellent list of variations and Pearson's school of biometricians, to some extent encouraged by Galton's quantitative theory of inheritance, were busy investigating many problems of genetics in humans and in lower forms.

Then in 1900 came the rediscovery of mendelism. At the same period De Vries' theory of mutation provided a method for the origin of discontinuous variations. Within five years the reports of the Evolution Committee, and the work of Davenport, Castle and Cuénot showed that mendelism applied to mammals as well as to many other types. Various color patterns in mice, rats and guinea-pigs as well as hair length and form in the latter were among the first cases to be recorded. Within another five years, that is to say by 1910, many new types of genetic material among animals were being used and the star of *Drosophila melanogaster* had appeared above the horizon.

Three years later the first of Morgan's books on genetics had been published. "Heredity and Sex" outlined and described the occurrence of sex-linkage and the genetic significance of the sex chromosome along lines earlier hinted at by McClung and by Castle. Definite proof of the correlation between structures in the germ cell and the behavior in inheritance of certain characters had been provided and the hunt for new facts was on. The small size, rapid breeding and economy of Drosophila were supplemented by the establishment of its cytological picture, which in comparison with all other animals then being studied was relatively simple and suitable for analysis.

These facts bore fruit, and in 1915 Morgan and his associates published "The Mechanism of Mendelian Heredity." It included maps showing the linear order of genes within the chromosome and opened up a whole new vista of definiteness in our ideas of the structure of the germplasm. The gene moved rapidly into the good social standing and warmed the hearts of biologists who had long been no more than politely aware of

[1] The sixth annual Sigma Xi address, Nashville, Tennessee, December 27, 1927.

the terms "pangens," "ids," "idants" and "biogens."

With the publication of the "Physical Basis of Heredity" four years later, Drosophila showed itself to be a bonanza. Under the superlatively skillful hands and minds of Morgan and his group it had given to biologists four general principles to add to the two fundamental discoveries of Mendel.

Morgan lists the six principles as follows:

(1) Segregation
(2) Independent assortment
(3) Linkage
(4) Linear order of the genes
(5) Interference
(6) Limitation of linkage groups

Of these numbers one and two represent the discoveries of Mendel and the other four those of Morgan and his associates.

The physical basis of heredity had thus been placed on a basis of definiteness never before dreamed of; the accuracy of results based on experiments carefully planned and predicted in advance had proven amazing. A really great victory had been won and an epoch-making advance had been recorded.

And then a question formerly as cold and cynical as the attitude of a present-day fundamentalist became warm and took on a tone of far greater intensity of interest. Medical men, lawyers, sociologists, the clergy and educators began to ask "Of what value are these facts to man?"

II

Before that question can be answered let us see why man's attitude towards biology in general and his own in particular has changed and had led him to ask the question as he has. There is no doubt that medicine, law, sociology, theology and education have all of them become much more interested in and considerate of the findings and possibilities of research in human biology than they were one or five or ten years ago. Their changed attitude has undoubtedly been one of the chief causes of the shift in public interest.

Without taking too much time it may be possible briefly to review some of the factors which have contributed to the increased attention now being paid to human biology.

The medical profession taking advantage of greatly improved methods of hygiene and sanitation has developed the preventive phase of its activities very extensively during the past few years. Schools and programs of public health have grown rapidly both in number and in extent. Mass programs dealing with prophylaxis of various types were a common procedure during the late war. They, along with the peace-time programs of public health, have helped to create in the mind of the medical profession a sympathetic attitude towards the subordination of the selfish rights of the individual to the larger needs of the group as a whole.

To strengthen this movement additional impetus came from other directions as well. Among the most interesting of the tendencies which has rapidly been developing to a point of general influence is the emphasis placed upon psychoanalysis and upon the interrelation between glands of internal secretion and various psychoses. The public fancy has been caught and held by the spectacular advances of knowledge in this field. As a result the medical profession more than ever before has shown a willingness to turn its consideration to the general natural biological processes which provide defense against disease and which cause variation in the activity of the glands of internal secretion. These facts, coupled with the realization that psychological abnormalities in many cases trace back to physiological bases which are themselves a definite part of human biology, have helped to increase

still further such interest once it is aroused.

In a somewhat similar way sociologists, recovering from their first skepticism of any "law of inheritance," have noticed the temporary nature of changes induced solely by alteration of environment and the persistence of the variations produced by genetic change. The researches of Goddard on feeble-mindedness have been among the powerful agents in carrying conviction to the doubter. So also have been the numerous studies reported by Newman, Muller and others on identical twins brought up in very different environments.

Whenever the sociologist, wearied by the pressure of facts of genetics upon his environmentally inclined mind, has attempted recourse to the mossy bank of neo-lamarckism or to the bubbling Watsonian spring of behaviorism he has been prevented from enjoying uninterrupted rest by a nasty and almost continuous noise. This noise is the insistent voice of those all over our country who notice the rapidly rising cost in the care of mental and social defectives. It introduces a particularly blatant note in what might otherwise have become merely a mild academic and scientific discord characterized by *dyspepsia intellectualis*. The raucousness of the new voice is caused by the fact that it originates from the average non-scientific taxpayer from whose purse the hands of the legislature biennially, with as little pain as possible, removes the funds to support those institutions such as state prisons, homes for the feeble-minded, the insane, the paupers, the diseased, the blind, the deaf and the unattached old people. It is a voice which like the sword of Alexander cleaves the Gordian knot of scientific argumentation with a far from gentle insistence on the point that the supply of defectives of various sorts should be controlled and diminished by preventing their reproduction.

Following closely on the heels of this agitation and pouring through the breach thus made, believing that the limitation of production of crippled, diseased, feeble-minded, epileptic or otherwise obviously defective children is both humane and economical the advocates of the spread of contraceptive information for health reasons have aroused a great and growing interest in the betterment of the race and the protection of childhood by the scientific methods of human biological research.

This, in turn, has brought out the fact that certain social or religious groups believe in the production of the greatest possible number of children of all kinds, whether handicapped and sentenced to a life of idiocy and suffering or not.

A healthy deterrent for this point of view is to be found in the community fund method of supporting charities. Because of the impersonal and fair attitude of those obtaining and spending the public funds for charitable purposes under the community idea the groups or organizations engaged in encouraging the production of unwanted and unfortunate children will eventually be recognized and isolated. As soon as this is done the next obvious and unavoidable step will be to insist that those so engaged pay the full expenses of the individuals produced under their guidance who later become public charges of any sort. Not long after that action is taken economic need will do the rest. In view of all these facts and a score of others the consideration of which time does not allow, it is not hard to understand the interested attitude of sociologists.

The legal profession also has been able to utilize advances in genetic knowledge. Mendel's Law has helped in the determination of parenthood and by its definite findings in the case of the inheritance of certain types of feeble-mindedness has greatly aided the advances made in legislation governing sterilization.

The records and family history of criminals also show in many cases such obvious biological foundation for abnormal behavior that supporting evidence for sterilization, under certain conditions, has readily been obtained. The law as a profession is notably conservative, yet it has among its members a steadily increasing group of outstanding individuals who are interested in obtaining more information on the methods of genetics to serve as the basis for constructive legislation.

The clergy has also become intensely aware of human biology.

Change in social attitudes may mean reform and reform in turn may mean discomfort to the existing stability of a ruling group. It is not surprising, therefore, to find one group of fundamentalist and conservative members of the clergy holding up as examples of filth and vileness those who are interested in the study of mankind from a biological point of view. On the other hand, the progressive members of the clergy are among the most ardent and alert followers of experimental science. Once these men realize that the acceptance of new truths does not mean loss of caste, they frequently become sufficiently radical to cause some embarrassment even to the most advanced of the experimental scientists themselves.

It is a healthy thing, however, to find such an active interest among the clergy and to see that many of them realize that the fate of international cooperation and of the world peace that would ensue depends very largely upon the characteristics of races and nations. These characteristics are many of them hereditary and so are biological in the most definite sense. Acceptance of this fact has done much to increase reliance in genetic differences and in the research which deals with them.

Educators also are peculiarly aware of the need for more accurate knowledge of the biological nature of the individual.

The great increase in our population has brought with it, quite naturally, an increase in the number of school children. The congestion resulting from this fact has spread from the lower grades of elementary school through all the higher levels to include even graduate or professional work. Selection in increasingly intelligent and strict form has been necessary because higher education is expensive and could not be distributed broadcast to any and every one who merely indicated their wish to receive it.

This has set educators to work in an attempt to develop a wiser and more honest method of rating mental ability than had formerly been in use. Such action was necessary if wise selection was to be practiced. Various mental tests have shown that mental ability is to a considerable degree definite, measurable and analyzable. They have also shown beyond any doubt that differences both in type of mental ability and in extent of general mental development are present in very young children. As a result, preschool units have been greatly developed. Child-study even with infants has become increasingly emphasized and will undoubtedly grow to even far more extensive proportions. No more impressive demonstration of the genetic and biological basis for individual differences in man could be obtained than are facts derived from such study.

The possibility that we may some day be able to predict achievement in the early years and so prevent waste of promising human material has come to the front with greater vigor and more hope than ever. As a result the mind of the educator is open to-day as never before to a sympathetic consideration of and interest in genetic research.

By very different but by converging roads the alert progressive phases of medicine, sociology, law, theology and education have thus met to combine in asking the laboratory geneticist the ques-

tion already referred to, namely, "Of what value to humanity are all your findings?"

III

It is very evident even from the very imperfect statement of the situation just made that there is a wide and somewhat awesome gap between the details of the structure of the germ cell in Drosophila and the wise direction of a program of improvement in human biology.

Jennings in his recent address as retiring president of the American Society of Zoologists expressed most intelligently, and to me most convincingly, the dangers and difficulties of applying in detail the conclusions drawn from results obtained in the study of the genetics of one form to the untried performances of another unrelated type of organism.

I shall not attempt here a comparison between the obviously widely divergent fields of plant and animal genetics but merely indicate a few of the differences which appear to me to be critical and unsurmountable barriers in the road of interpreting the detailed genetic problems of man on the basis of work, no matter how skilful, done with Drosophila or other insects.

The object in doing this is in no way a desire to discredit the splendid work done in the field of insect genetics. It is merely an attempt to show that the gap between the laboratory phase of experimental genetics and the interest in human biology will not be bridged by research in forms as widely separated from man as are the insects.

The insect is remarkably definite and fixed in a biological sense. From the very egg—itself more or less definitely organized into zones or regions—it shows a tendency to specialize its structures for detailed and well-defined objectives. The segmental arrangement of antennae, body and legs is further evidence of detailed morphological differentiation. The compound eye is a sort of declaration of morphological policy which is characteristic of insects.

The normal physiological responses of insects are also very detailed and definite. The freedom of secondary sex characters from the influence of secretions of the gonad is a typical example of the independence of organs and tissues which exists in insects. The phenomenon of a complete metamorphosis is also an indication of the discontinuity and highly evolved organization of the developmental process in insects.

The vast number of instinctive responses in insects shows that their psychology shares to a high degree the particulate and mosaic type of constitution that applies to their physiology and morphology as well.

It seems quite natural then to find that in most of those insects already studied the germ cells are highly definite and regularly organized. One would expect nothing else if the germ cell is to be considered a characteristic part of the individual and a reasonable precursor to the organism arising from it.

Man lacks much of this definiteness. Beginning with an egg that appears to be more completely interdependent in its various parts than is that of insects he develops during his embryonic life in a carefully controlled environment. Constant internal temperature, moisture and food conditions allow the free development of a balanced and elastic type of organism.

Interchangeability of body fluids, dependence of form, rate and extent of growth and maturity upon internal secretions—and relative elasticity and indefiniteness of mental processes all are directly in contradistinction to the conditions found in insects.

It would not be at all surprising if in mammals the internal organization of the germ cell itself, including the interrelationships between cytoplasm and chromosomes and between chromosomes

themselves, was much less definite and predictable than is that of insects. In fact a recent paper by Miss Swezy in *Science* showing that the ordinary white rat may have either forty-two or sixty-two chromosomes without marked morphological change seems to prove that in one case at least such is the case.

It is true that there are chromosomes in insects and in mammals and that there is likewise evidence for mendelian inheritance in both forms. To draw close homology, or even analogy, however, between the detailed genetics of man and of insects would be exceeding our present knowledge. There is a real gap between the two forms.

There is, however, already in position the foundation of the main support of the bridge over the gap referred to. It has not yet been built high enough for a level and comfortable transition, but it has definite possibilities and as I see it must be constructed before we can expect much real progress in human biology. The structure to which I refer is the steadily growing mass of information being obtained in the field of research in the genetics of the laboratory mammals.

IV

To collect data which will help to bridge the gap we must observe certain general rules of experimental procedure. First, the problems to be investigated must be of interest to man. One can not expect by mammalian genetics to extend the influence of or deepen interest in human biology unless the problems investigated have some connection with those of the larger human field. Fortunately, the great majority of problems which are capable of study in the laboratory mammals are of just that sort—as I shall try presently to show.

It is also necessary that the problems connect with known genetic phenomena; that they trace back to some sort of relationship with research in genetics of lower animals or plants. Unless this is the case the benefits of the general principles and fundamental values of the relation between biology and its more exact sister sciences, physics and chemistry, are apt to be lost sight of. The bridge, in other words, if it is to function properly, must have well-developed approaches from both sides.

Besides being of interest and value to humans and being based on sound genetic theory the problems must be capable of investigation in economic and suitable material. The last requirement is, of course, purely practical, but for the purposes of successful experimental procedure it is essential. Among mammalian material the types which are favored for experimental work are at present practically entirely confined to two carnivors and four types of rodents.

Cats offer interesting color differences, certain structural variation such as short tail and polydactylism, variation in length of hair and the best case of sex linkage known in laboratory mammals. For breeding purposes in great numbers, however, they are a bit too non-social and are subject to epidemics.

Dogs have a great wealth of color, varieties and of morphological, physiological and psychological differences. In these respects and in their small number of chromosomes they are unique among laboratory mammals. They are slow-breeding and expensive to raise, but they will undoubtedly eventually be used on a large scale.

Among rodents, rabbits are the largest and slowest breeding of those used. They have a few genetic morphological variations but a good list of color differences and between some varieties marked difference in size. They have also a good reputation as material for experimental medicine and are valuable for serological experiments.

Guinea-pigs (in spite of excellent press agent work by Ellis Parker Butler) are not very rapid breeders. Their morphological variations are almost as

scarce as rabbits and their average number of young per litter (between two and three) is very small. Their number of color varieties and their chromosome conditions are not radically different from those of rabbits.

Two types of rats provide distinctly better material than either of the foregoing. With a fair number of color varieties they combine a high degree of fertility and relatively rapid rate of maturity. Their size makes them economical of space and convenient for most forms of operative technique. Mice of two genera (*Mus* and *Peromyscus*) appear, however, to be even better material than is any one of the other types. Only slightly inferior to rats in respect to litter size they have many more color varieties, more morphological types, far greater size differences and a number of distinctive physiological characters. Three available species of the genus *Mus* afford an excellent chance for the study of hybridization and its accompanying phenomena. The mechanical advantages of mice are also great. They are only about one fifth as large as rats and therefore are much more economical of food and space. They mature much more rapidly and provide embryos of convenient size for histological study and sectioning *in toto*. In my opinion they offer the best material for experimental genetic work with mammals.

With this brief review of the qualities of different types of available material let us consider the fields of research, particularly of interest to mammal geneticists.

V

There are at least five great groups of genetic problems which are capable of successful investigation in laboratory mammals and which fulfil all conditions outlined above, being of interest to man and in close contact with other fields of experimental genetics. These problems include the genetic bases for size and growth, fertility and sterility, susceptibility or resistance to disease; lethal action of genes during development and psychological differences.

Although there will be undoubtedly interrelation between the five fields they will each be able to provide ample chance for fundamental and continuous research. Let us review each of them briefly.

(a) Size and Growth

Investigations by Sollas reported soon after the rediscovery of mendelism showed that dwarfism in guinea-pigs was inherited as a recessive, in some way related to sex. Castle showed that ear length in rabbits was inherited but by no simple method; MacDowell carried the problem farther in a detailed study of body weight and skeletal measurements in rabbits, Wright and Castle both contributed to the discussion of the nature of the genetic factors involved. Detlefsen, in recording a cross producing hybrids between the common guinea-pig and a related wild species, showed the relation of the growth rates of the three types. The two greatest opportunities for the study of size inheritance in mammals are however as yet practically or entirely undeveloped. Dogs, in which artificial insemination is possible and where body weight is fifty times or more as great in such a variety as St. Bernards as it is in chihuahuas, are splendidly fitted for use in investigations of size inheritance.

A cross between *Mus musculus* and *Mus wagneri* would also provide excellent material. The size difference is striking. It would be easy to back-cross the hybrids with either parent and to save the skulls and long bones of thousands of animals in each generation. There are enough color genes already described in *Mus musculus* to run a good chance of finding any existing linkage between genes for color and those for size.

In addition to factors involving general size and growth there have been several cases of localized growth phenomena which have been investigated. The inheritance of short tail in mice, dogs and cats has been shown in each case to be a mendelian dominant over normal tail length. Polydactylism in guinea-pigs and cats is dominant, while when associated with other digital abnormalities in mice it is recessive and influenced by modifying genes; an abnormal jaw and buccal cavity in mice is also recessive and lethal. Uncontrolled or abnormal growth of certain teeth in rats seems to occur in families, although its method of inheritance is not as yet clear.

The great morphological variations in dogs have provided and will continue to offer a splendid field for study. The shortened and crooked legs of the dachshund and the curled tail of the chow have proven to be mendelian dominants. Recently, recognizing the great value of dogs as genetic material, Stockard has started a series of experiments to determine the relation of morphology to glands of internal secretion. The results will be awaited with great interest.

The work of Davenport on the inheritance of stature and that of other investigators on different forms of dwarfism in man show that such comparative studies would be valuable. The genetic importance of different local variations in morphology are also well known in man. Polydactylism and brachydactylism are inherited, and the latter may possibly be lethal if present in a homozygous condition according to the work of Mohr—there is ample evidence that the study of these problems in laboratory mammals would have a direct interest for human biology.

(b) Fertility and Sterility

Differential fecundity and fertility in man lie at the foundation of the relative rate of increase of different nationalities and social groups. Laboratory mammals are well adapted for study in this general field.

The opportunity to make specific crosses is excellent. Detlefsen found a most interesting case of partial sterility related to sex in hybrids of *Cavia rufescens* and *C. porcellus*. Several investigators have found diminished fertility among F^2 and subsequent hybrid generations in a cross between Japanese waltzing mice (supposed to be derived from *M. wagneri*) and common mice (*M. musculus*). Crosses between *M. musculus* and *M. wagneri* and *M. musculus* and *M. faeroensis* have recently been made and will be available for further study.

A more accurate measure than ever before of fertility of female mice is provided by the technique developed by MacDowell which enables us to count the actual number of eggs liberated at any ovulation. Among dogs the average litter size of such breeds as airedales is very high, probably in the neighborhood of nine, while the greatest number in such breeds as chihuahuas is two or three, thus providing a splendid chance to determine whether the difference is inherited. Injections of extract of the pituitary has been shown by P. E. Smith to result, in mice, in greatly increased numbers of eggs at any one ovulation in mice. As many as twenty-nine implanted embryos have been counted in a single pregnancy by Smith, although the largest litter record at birth among the tens of thousands of cases in our laboratory is fourteen. By this technique we can evidently introduce an interesting experimental factor. In addition to this the effects of temporary sterilization induced by X-rays or other means is open to study. It is a well-recognized and easily obtained phenomenon.

Although these things are apparently disconnected, they all have a direct bearing on human genetics. So also have

the numerous investigations made on the effects of reproductive overwork, the relation of nutrition to fertility and the effects of these various things on the course of the oestrus cycle.

The possibility of controlling the sex ratio by altering experimentally the body fluids of the female reproductive tract, the modification of the sex ratio by other agents such as X-rays, hybridization or artificial insemination with sperm of different ages are also matters for study in laboratory mammal material, which is rich in its opportunities in these and in allied fields.

(c) Susceptibility or Resistance to Disease

There are two general types of pathological conditions which will be open to investigation in laboratory mammals. The first of these deals with infectious diseases.

Wright has shown that inbred strains of guinea-pigs may differ from one another in respect to their susceptibility to tuberculosis. Hagedoorn has published evidence which he believes demonstrates hereditary differences in susceptibility to an intestinal infection in hybrids of waltzing and tame mice. Tyzzer has described a microorganism which lives within the cells of the liver and causes death to Japanese waltzing mice but not to ordinary non-waltzing varieties. There is undoubtedly a great field for research in this general line of work. Slye has frequently shown clearly that there are particular strains and families of mice in which death due to infection of various types is much more common than in others—thus suggesting hereditary differences in this respect.

A second type of pathological condition resulting in structural or functional defects is known to be genetic in several cases. Cole has described the inheritance of paralysis agitans in guinea-pigs as a mendelian recessive. Stockard and Papanicolaou found a number of cases of disequilibration and nervous tremor in successive generations of guinea-pigs, following treatment of the ancestral generation with alcohol fumes. Przibram found hereditary deafness common in blue-eyed white cats, and Yerkes found that after the sixteenth day all waltzing mice are deaf. In this case waltzing and its accompanying deafness are inherited together as different manifestations of the same mendelian recessive. Keeler has recently described a rodless condition in the retina of certain albino mice. Here also a simple recessive character is involved. Jones has obtained in experimental animals a strain of rats in which reduction of one or both eyes is inherited but not in a simple mendelian fashion. In the descendants of X-rayed mice Bagg and the writer have described inherited eye and foot abnormalities and Bagg has recorded absence or reduction of one or both kidneys, which is also inherited.

In man there is a whole series of structural or functional diseases which are inherited. Hemophilia, nystagmus, hypospadias, Huntington's chorea, diabetes insipidus, xeroderma pigmentosa and alkaptonuria are examples chosen at random to show a wide range of characters which may be affected.

In addition to the conditions already mentioned the hereditary tendency to form mammary and other forms of cancer has been investigated. A number of investigators, Tyzzer, Strong, Haaland, Loeb and Lathrop, Slye, Lynch, W. S. Murray and the writer have published a considerable body of papers in the general field of genetics of cancer. At present it seems as though in mice mammary cancer behaves as a mendelian dominant, the manifestation of which is limited normally to the female sex. Slye's work shows also that different families or strains may be developed in which the particular localized types of tumors are relatively constant for any particular group. Many of the types

other than mammary cancer are in no way sex-limited. The evidence for the exact method of inheritance of the tendency to cancer in man is naturally not so direct or so easy to accumulate. There is no reason at present, however, to lead one to believe that the conditions in man are widely different from those described in mice. It can easily be seen that the genetics of comparative pathology will be one of the most important divisions of the general field of mammalian genetics as future developments are recorded.

(d) Lethal Action of the Gene During Development

Lethal action of a mendelian gene in animals was first discovered in mice. Embryological research by Kirkham, Ibsen and others established the correctness of an hypothesis based on experimental genetics on the inheritance of dominant yellow coat color in mice. The hypothesis advanced by the writer and Castle (1910) was that homozygous yellow mice started but did not complete their embryonic development. Such being the case it follows that an excellent chance for investigating the nature of lethal factors is offered.

In mice also a dominant type of spotting, producing when in combination with the ordinary piebald spotting a variety known as "black-eyed white," also acts as a lethal independent of yellow coat color. Detlefsen and others have recorded the appearance at birth and the survival for a few days thereafter of a pale whitish anemic type of young. This they have described as being the homozygous black-eyed white. It may be that such is the case. The writer, however, has found what appear to be similar young in the cross of black-eyed white by piebald from the same stock. Since all black-eyed whites in that case are heterozygous it would not be possible for homozygosity of the factor for dominant spotting to have caused the lethal action. Wriet has described a dominant spotting in merle "dunkerhunds" which causes death if present in a homozygous form. The short-tailed variation in mice is also described by Nageli as a clear case of dominant lethal. Mohr, as it has been stated above, has published some evidence that brachyphalangy in man acts like a lethal. The writer and Gibbons have tried to show by a statistical analysis of human pedigrees of hemophilia and color blindness that there were certain physiological factors at present unidentified but lethal when present in any situation unbalanced by a normal gene. In the cases recorded they chanced to be sex-linked and therefore distorted the sex ratio so clearly as to be recordable statistically.

The relation of lethal factors to the occurrence of still-births in man is a matter for attention and research. It should prove to be a fruitful and interesting field of cooperative endeavor between mammal geneticists and the medical profession. Data obtained from the Sloane Maternity Hospital in New York showed that there are fewer still-births when the parents are from different nationalities than when they are of the same. Whether this means that the embryo in a relatively inbred race was not able to survive and that the embryo derived from a cross between nations showed heterosis or hybrid vigor and so survived is not known but should be further investigated.

Lethal genes are interesting not merely because they may account for considerable lowered fecundity through early mortality but also because in studying the process of disintegration of the embryos killed by lethals we may be able to get a better idea of the nature of growth, morphogenesis and of the development of the gene's activity at different stages in ontogeny.

(e) Psychological Factors

The evidence of inheritance of general mental ability in man is strong

enough to be an impetus to further research. From Galton's study of men of genius to Wood's more recent investigation of the same general topic and Banker's research on families of Harvard alumni a mass of facts has been piling up to show the hereditary basis for ability.

Special abilities also give evidence of a genetic foundation. The work of Stanton, Seashore and others in the analysis of musical ability and in tracing the inheritance of its various component parts sets a standard for this type of investigation.

The field of genetics of psychological characters in laboratory mammals is almost a new one. The relation of habit formation, associative response, learning, memory and other psychological phenomena to various genetic phenomena, such as inbreeding, hybridization, overcrowding, isolation, malnutrition, and to the activity of the glands of internal secretion will offer important fields of research for decades to come. Bagg and Vicari have already independently shown differences in rate of learning between inbred strains of mice and the latter has demonstrated an effect of heterozygosis following hybridization of two such strains. MacDougal believes that he has evidence of the inheritance of an acquired habit or ability in rats. Pavlow has described experiments with mice in which he attempts to prove that the effects of learning are inherited. His work has been repeated with negative results by other investigators and might well have followed rather than preceded a careful and extensive study of the normal racial and individual variation in the process of learning in mice.

Dogs will also provide admirable material for the study of the genetics of psychological phenomena. Habits, such as "pointing," "setting," "springing," "giving-tongue," "going to earth" and a number of other natural responses, can be studied and compared with the great number of types of habits following training that will bring out marked individual differences in ability.

Both dogs and mice have enough physiological and morphological variations to provide an excellent opportunity for the investigation of linkage between psychological and physical characteristics. Possibly from such research will come more definite and extensive knowledge of the nature of many of the fundamental mental processes.

The importance of such investigation to education is very evident and when generally recognized is certain to mean increased experimentation and cooperative research between schools of education and departments of mammalian genetics.

The necessarily imperfect and hurried survey of five broad fields of possible investigation can now be considered from the point of view of four great general unanswered problems. These are the permanency of genes, the relation of soma to germ plasm, the nature of the gene as shown by its activity during ontogeny, and the possibility of producing genetic change by gradual action of various substances.

(1) The Permanency of Genes

The recent work of Muller has shown that in Drosophila the rate of genetic change by mutation is very rapid. So high is it, in fact, that the usefulness, in that material, of the pure line hypothesis of Johannsen, and the genetic fixity and relative unity of inbred lines seem very much in doubt. It may prove a great handicap to future research to have a form so subject to mutation that its stability, when desired for testing purposes, is not reliable.

It will at all events be desirable to investigate, in addition, such forms as mammals, in which the rate of mutation at various ages and under different types of physiological or other environment can be observed. We know from

the work of Strong and the writer that in mice the normal and characteristic development of the individual proceeds from an initial phase of relative undifferentiation to the peak of physiological individuality at the young adult stage of the individual. As the animal approaches senility there appears to be evidence that its degree of individual differentiation again decreases and that this condition continues until the death of the animal. Senility thus at least superficially resembles a physiological "second childhood."

If now, as the work of P. E. Smith shows, it is possible to bring on the process of ovulation at an earlier than normal age by injections of anterior lobe of the pituitary, we shall be able to increase the scope of our field of experimentation. It may also be possible to prolong ovulation in mice which in other respects are approaching senility by the same method or by some other type of rejuvenation process. This will enable us to study rate of mutation under varied internal environments. Quite as good a chance of studying the permanency of genes is afforded in males of different ages.

The effects of changes in the gene would, of course, be measurable in respect to rate of maturity, degree of fertility, length of life, rate of growth, susceptibility to disease and a number of other processes which are very difficult to study experimentally in animals with too short a life span. The additional fact that transplantation of various normal and neoplastic tissues in mice have given us a means of analyzing the genetic nature of many physiological processes is a further indication that variations by mutations other than those of form or structure will be more easy to detect in these animals than they would in forms where transplantation is not so easy.

(2) Relation of Soma to Germ-plasm

The classic experiment of Castle and Phillips in which black young were obtained from eggs derived from ovaries of a black female guinea-pig transplanted to the body of a white female gives clear indication of the opportunity which exists in mammals for research on the relation of soma to germplasm.

While the particular characters used by Castle and Phillips as tests of whether an influence of the foster-mother could be detected were not ideal, there are many others which can give us information of a more accurate nature. The use of a color character of the type involved in the difference between colored and albino animals is not as well calculated to demonstrate minor degrees of modification as would be a test involving such differences as those of spotted animals as contrasted with solid colored ones, or of the more subtle physiological characters, such as susceptibility to transplanted tumor or inherited differences in size. In these cases, as well as in psychological traits, it is easier to detect the minute quantitative variations or modifications which are not so readily detected in the case of color characters of the sorts used by the investigators referred to.

To provide an additional field of research, the possibility of regeneration of ovarian tissue in mice, recently described by Davenport, suggests that a new line of approach to both changes in mutation rate and in the relationship of germ-plasm to soma may be developed.

The techniques of MacDowell and of Nicholas show that we may, with care, expect to develop methods by which we can obtain more accurate first-hand knowledge of what is going on during the stages of ovulation, fertilization and embryonic development. This should aid greatly in solving certain of the problems of relationship between maternal and embryonic tissue, and so contribute directly to the general question of the inter-relationship of soma and germplasm.

(3) The Production of Genetic Change by Gradual Treatment

Mammals are peculiarly fitted for experiments in this general field. Besides providing us with a wealth of different types of characters to be studied, time is afforded during the various stages of the development of the individual so that we may analyze with considerable accuracy both experimental treatment and its effect.

Stockard and Papanicolaou's work in guinea pigs with alcohol fumes, and Guyer and Smith's experiments with rabbit lens antibodies are two well-recognized cases in point. In addition, Bagg and the writer have reported morphological genetic variations in the descendants of X-rayed mice, and J. M. Murray has published a preliminary note on some of the direct effects of irradiation. Jones has cooled and dried the Fallopian tubes and uterus of rats of the selected inbred Wistar Line "A" strain in the early stages of pregnancy. Certain of the young derived from implantation following this treatment had defective eyes. The defect appears to have been inherited. Numerous investigators have shown direct effects on growth, size and fertility by dietary changes; and Johnson (unpublished work) has found changes in the same direction by repeated exposure of young mice to ultraviolet light. These investigations suggest that repeated treatment by any or all of these means can be made a method of testing whether germinal change can be induced by gradual modification of environment. Mice which commonly give four generations per year and yet have an individual life span of two years or over are ideal for work of this type.

The possibility of the transmission of immunity slowly acquired is also worth careful study and is capable of much more interesting analysis than has yet been given it.

By using these and other methods the old but always interesting question of "use and disuse," if taken in its broadest meaning, will, in laboratory mammals of known genetic types, be capable of new and more important investigation under experimentally changed environments.

(4) The Behavior of the Gene during Ontogeny

After the gene has been located and the chromosome mapped with great accuracy, we shall still need to know all that we can concerning the gene as an activator, deterrent, inhibitor or other influence on structure and function during ontogeny.

We can not avoid the fact that until it is translated into terms of activity the gene will remain an inert locus in the gamete and will not be analyzable or even describable in any significant terms. It is not at all necessary to subscribe to the old fixed correspondence between gene and character which lay at the basis of much misunderstanding and discussion, following the earlier work of Cuénot and of Castle. One may cheerfully admit that many genes influence the appearance of every character and take part in its development, or that any gene may influence many or all characters of an individual organism. One may also willingly agree that the gene is the fundamental basic and localizable unit in genetics. In spite of all these things, however, we are also forced to admit that a gene remains at present without any distinguishing characteristic unless it is measured in terms of developmental processes which we have been accustomed to call "characters."

For the investigation of such processes laboratory mammals are remarkably, if not uniquely, adapted. With internal moisture and temperature controls, with a relatively continuous type of development, with a life span and size scale

fitted for the detection of minute quantitative variation in rate, extent and form of development, they are as well fitted for the advanced study of the activity of the genes as are any organisms at our disposal.

Those interested in problems of theoretical genetics; those engaged in medicine, sociology, law, theology or education; those interested in human biology, racial modification, or even individual development from any angle, may all combine in awaiting advance in experimental studies of the types mentioned.

The rapid multiplication of mankind has forced the attention of man upon himself and his neighbors. His attention will remain there, his study be focussed there, his major problems will arise there, and there his chief success and failure will be experienced from the present time until a cataclysm reduces his numbers by hundreds of millions, or his control of his own physical and psychological progress, based on sound research, is determined and insured by inspired scientific leadership.

CAN WE LIVE LONGER?

A MEDICAL VIEWPOINT

By Colonel HARRY VANDERBILT WÜRDEMANN
SEATTLE, WASHINGTON

FROM the clinical point of view of the individual the answer to this question must be unqualifiedly in the affirmative, for history shows marked increase in average longevity, biology predicates longer life and science is gradually gaining the victory in the reduction of infant mortality and over-communicable disease.

Let us go to the ancients for a moment and see what was their expectation of life.

The Scriptures state, "And all the days of Methuselah were nine hundred and sixty-nine years; and he died." The average age of the oldest Biblical characters according to this history was five hundred years. We who are living in the progressive Northwest, and not in Tennessee, now know from the evolutionary study of civilization that the ancients reckoned time by the moon, and so the oldest historical character according to this computation would have been seventy-five when he passed on—a fair old age for those times of war, want and pestilence, when probably a virile man begat a hundred or more children, 90 per cent. of whom perished in infancy, three fourths of the remainder before physical possibility of perpetuation of the species.

In the tree-climbing days, before homo sapiens could speak, only those who were most resistant to disease reached maturity, many of them dying early by accident or being killed by savage beasts, or, in times of scarcity, eating their own young and infirm.

Then came family life with the necessity of protection of its members by the adult male, and the beginning of conflict with his own kind, with killing off the weaker ones at an early age. Then with the beginning of civilization, the clan, the tribe and finally the nation were developed; the strife between the elements causing occasional massed killings and massacres. The most important of all factors presenting rapid increase of the population, however, was the closer bodily contact in houses and gatherings through which infectious diseases were communicated, mainly by parasites of man traveling from one sick person to another person, afflicting them with violent and deadly disease. Only those who had established a certain degree of immunity then survived. Our ancestors were all lousy (pediculosis), daily bitten by bugs (cimex), and they came in contact with all sorts of disease germs. They were daily stung by mosquitoes (anopheles, the malaria carrier, stegoneia, the yellow fever carrier, and others), and fleas were constant companions. They spat around anywhere, spreading tuberculosis and pneumonia. They washed but seldom, their bodily odors being such that they would not be permitted in any modern private house or public assembly. They were indeed a dirty and intemperate lot even up to a few generations ago, and they knew nothing of the prevention of disease before puberty. The young men went off to the wars and were killed or were beaten, tortured or worked to death if they remained on the estate of their

[1] Radio addresses, KOMO.

masters. Thus in those days the probable expectation of life was only twenty-five years.

By 1900 it had doubled, reaching approximately fifty years (49.24 years for a new-born baby), and in 1926 had risen to 57.32 years. Even in overcrowded New York City during the last fifty years the expectancy of life has increased nearly 60 per cent. How much better it must be in this favored region of the Northwest, where we have good food, where we lively largely out of doors and where many diseases that depopulate other peoples are but academically known.

Thus by sanitation and the lessening of sanguinary conflicts a certain advance has been made in the extension of human life, and much of this advance through the medical profession, whose work it is to prevent disease as well as to cure it.

But what are we doctors doing to prolong life after disease or injury? It is recognized by physicians and sanitarians that fully one third of the deaths are induced by preventable causes and can be warded off for a time, especially in these enlightened United States of America.

Our whiskey has mostly been taken away from us; diabetes is cured by insulin; syphilis by salvarsan; tuberculosis, typhoid, diphtheria, by inoculation and serums, smallpox by vaccination. Even the common cold, the forerunner of many deadly diseases, is amenable to serum treatment. The people generally know these facts and seek early treatment. Sweeping epidemics of smallpox used to take off 10 per cent. of our ancestors. Now no one should die from it; in fact, no one can take it if properly vaccinated. In my early practice 60 per cent. of children with diphtheria died, now only 6 per cent. There should be no more typhoid or other such diseases as were common up to twenty-five years ago. We know the menace of the house fly, the flea and the louse.

But, how about the reported increase in cancer, in heart disease and circulatory affections which take off 50 per cent. of people over fifty? These are degenerative diseases of advanced life and are apparently more prevalent because they are properly labeled, *i.e.*, diagnosed, and because we live longer. Even within the last few days Mr. Lasker has given to the Medical Department of the University of Chicago one million dollars to study them and so we hope for results such as have come from the Carnegie, Rockefeller, Vanderbilt and other foundations—a wonderful use for these swollen fortunes.

The United States Government through the Agricultural, State, War and Navy Departments prevents the entrance of plague carriers and defectives by more or less strict inspection of immigrants and has instituted researches into the microbic, vegetal, animal and human origins of communicable disease.

There is no physiologic reason why human life can not be prolonged from the present expectation of sixty-five or even that of the Psalmist of four score years and ten. "Yet his days shall be one hundred and twenty years" (Gen. 6:3).

There seems to be a rule of mammalian life that its duration is five times the time of the growth of the bones. This is about twenty years for man. Therefore we should live to be a hundred before the complicated system of cells we call our body ceases to reproduce offspring. In truth we die daily, but these new cells are born every second of our existence.

The cell is immortal and if fed properly, as far as we now know, the pulsation of life may go on forever. But immortality is incompatible with such a highly organized association of cells so senility and death must ultimately ensue.

There are, however, psychologic and economic reasons why some of us should

not live longer. Would not society and the average person be better off were the 2 per cent. of insane, the 5 per cent. of morons, the nearly million of criminals and the five million of asocials, out of the 118 millions of Americans, to die off in early life before they have a chance to perpetuate their defects in their progeny?

Applied eugenics may some day take care of this question.

From the evolutionary point of view of the race as a whole, the prospect is for increase in the average weakness of the adult constitution; for the germ cells seem to be deteriorating through the multiplication of sublethal genetic mutations. In plain language, weak parents are breeding just as many children as ever, which inherit their defects, while those with the best bodies and brains are having smaller families or no children at all. The race may reach the position of equilibrium of equalization which will determine the length of man's days.

It is indeed worth while for the normal individual to live as long as he can be useful to his fellow men. Don't be like Methuselah, whose only result of his 969 years shows in the sentence, "He begat Lamech."

Many of the finest achievements in statesmanship, literature, medicine and the arts have been made by men of sixty or over. Is not Dr. W. W. Keen at ninety-one one of the foremost physicians of the world? Edison is at work at eighty; the statesmen, Arthur James Balfour, eighty-nine; Elihu Root, eighty-two; Von Hindenburg, eighty; Clemenceau, eighty-six. The astronomer Galileo, the philosophers, Herbert Spencer and Lamarck; Browning and Goethe, the poets, Verdi the composer, produced their masterpieces between the ages of seventy and eighty-five. Titian painted at ninety-eight. Sarah Bernhardt and Joseph Jefferson acted at seventy-five. Most of the successful generals in the World War were far past the American War Department retiring age of sixty-four.

It is certain that productive mental activity is greatest after the age of forty, provided that the health of the individual is good and that cares and responsibilities do not take away his ambitions. The preamble to our constitution guarantees the pursuit of happiness to the individual, but he must have his health insured as well as his ambition for productive work conserved to make it worth while to live longer.

The sociologic aspect of long life will be discussed by Professor McKenzie, of the University of Washington.

A SOCIOLOGICAL VIEWPOINT

By Professor R. D. McKENZIE
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DR. WÜRDEMANN has shown you that the average length of life has increased considerably during the last few decades as a result of the increasing efficiency of medical science. But what is meant by the average length of life and how great has the increase actually been? The average length of life simply means the life expectancy at birth. In 1920 this was 55.33 years for white males in the United States. In other words, if one hundred thousand babies born on the same day start on the journey of life together the average age at death would be fifty-five years. The Bureau of the Census estimates that during the 120-year period—from 1800 to 1920—there has been in the United States a gain of

twenty-five years in the average length of life. The bureau has published three life tables since the beginning of the present century. The 1901 table places the average length of life at forty-eight years, the 1911 table places it at fifty years and the 1920 table at fifty-five years. It will be observed that there has been a rather rapid increase in the average length of life during the last two decades.

Let it be clearly understood, however, that these gains are for the *average length of life*. They do not signify that the number of persons reaching extreme old age is increasing or that the maximum span of life is becoming greater. In fact, until very recently the life expectancy for all ages over thirty-two years was showing a tendency to decline rather than increase. In other words, until 1920 a person of forty had a poorer chance of reaching say the age of sixty-five than a person of forty had in 1890 or in 1900. The 1920 life table, however, showed a more favorable expectancy for persons of middle life. But it still showed the life expectancy of persons over eighty years of age to be less than for the corresponding age group twenty years previously. Similar conclusions may be drawn from an analysis of the regular census data. According to the United States census for 1920 only 2.6 per cent. of the population had attained the age of seventy years or more. The ratio of this age group in 1910 was 2.3 per cent. of the total population and in 1900 exactly the same. So you see the percentage of persons who reach the allotted span of three score years and ten is remaining about constant. However, when we consider real old age, persons who have attained one hundred years or more, we find a still poorer showing for longevity. In 1880, when the United States had a population of fifty million people, the census listed 4,016 persons as having attained the age of one hundred years or more. But in 1920, when the population had reached one hundred and five million, the number of persons listed as one hundred years of age or over was only 4,267. In other words, although the total population of the country had increased more than 100 per cent. during this forty-year period the number of persons of one hundred years of age or more had increased only 6 per cent.

It is quite clear, therefore, that however successful medical science has been in combatting the diseases of childhood and youth it has not as yet added anything to the maximum span of life. Human existence is a product of two sets of forces: heredity and environment. Longevity, as all physicians agree, is largely a result of heredity. Medical science and social control in general may furnish a favorable environment, but they can not change the hereditary traits of the human organism. Apparently the only way to extend the span of life is by carefully guarding our long-lived stock.

Let us now consider the possibility of further increase in the *average* length of life. It is common knowledge that the recent increase in the average length of life has been due primarily to the saving of babies and children. Fifteen per cent. of all deaths occur among infants under one year of age. Every child saved, therefore, adds about fifty-five years to the possible life of the community, whereas a person saved at the age of say forty-five adds only about ten years. The rapid progress which medical science has made in recent years in combating the germ diseases of childhood and youth is apt to leave the impression that similar progress can be continued indefinitely and that eventually the average length of life may be seventy, eighty or ninety years. Such, however, is not at all likely to be the case. Now that most of the germ dis-

eases are under control, science has to battle with the more profound constitutional ailments, such as organic diseases of the heart, cerebral hemorrhage, cancer, Bright's disease, all of which are on the increase. In this respect the individual rather than the wholesale method must be employed and the results will not be so pronounced. In fact, medical science has already reached the point of diminishing returns so far as the reduction of the death-rate is concerned. During the last few years, according to Metropolitan Life figures, there has been no gain at all in the average length of life.

Then there are other factors to be considered over which medical science has no control. Some philanthropist, such as John D. Rockefeller or Andy Gump, may offer millions for the capture, dead or alive, of the last bug that destroys the human organism, but this does not in itself guarantee that all the enemies of human life will thereby disappear. Man has ways of destroying himself that are quite as effective as those of the invisible parasite. To prove this statement we have only to review the increasing death-rate from violent causes, not to mention that from the so-called degenerative diseases. Our fatal accidents claim one hundred thousand lives a year and the rate is steadily increasing. In 1926 twenty-five thousand persons were killed and seven hundred and fifty-nine thousand severely injured in highway accidents alone. In other words, a city about the size of Bellingham was completely wiped off the map during the year and one twice the size of Seattle converted into a hospital for the maimed and crippled. We are living in a technical age of movement and speed. Every invention that gives us mastery over distance, such as the railway, automobile and airplane, ushers in new causes of violent death. The death-rate from homicides has more than trebled during the last two decades and that from suicides has shown no tendency to decline. The death-rate from drownings is increasing and that from alcoholism has multiplied fourfold since 1920. Unless we are convinced that *homo* is *homo sapiens*—and so far there is no evidence to support such a belief—we can not expect a reduction in the death-rate from violent causes. In a word we can not hope for much greater increase in the average length of life.

But aside altogether from the possibility of increasing the average length of life there is the further question of the desirability of such a result. It is quite clear that any increase in the length of life of competent persons is socially advantageous. And even more so now than in the past, for as society becomes more complex it requires of its citizens more brains and technical skill in the solution of its intricate problems. But by increasing the average length of life we necessarily bring to maturity, and frequently to extreme old age, a host of nature's inferior progeny that would otherwise have fallen by the way.

Considered from a crude economic standpoint society benefits by the death rather than by the life of its misfits. It is impossible to estimate the economic burden that we are imposing upon ourselves by prolonging the lives—or rather the deaths—of socially incompetent persons. According to the latest census figures the United States has in its public institutions seventy-five thousand blind; forty-five thousand deaf and dumb; forty-three thousand feeble-minded—remember this is only the number interned in public institutions, God only knows how many feeble-minded are driving high-powered machines along the highways to-night. In addition there are in our public institutions nine thousand epilepties; two hundred and sixty-eight thousand mentally diseased; seventy-eight thousand paupers, 68 per cent. of whom are over sixty years of age. There are also in this

country over seven hundred thousand persons so severely crippled as to be unable to earn their own livelihood. Then there is the criminal class. The latest census of our penal institutions lists one hundred and twelve thousand steady boarders and four times that number of temporary visitors in the course of a year. This army of incompetents, totalling well over a million and a half, gives a very inadequate picture of the economic burden entailed. It tells nothing about the host of dependent persons who are supported within private homes or by private institutions and agencies.

Of course I do not argue that the best way to deal with social incompetents is to let them die. It would appear to be a much saner policy to prevent their being born. But this is another question, a subject for another debate. The main point to remember is that under present conditions advance in the average length of life is not in itself an unmitigated blessing.

THE OIL GAME

By the Late EDWIN THEODORE DUMBLE[1]

SOME months ago as I was walking along the bank of a creek which flows beside the old ice pond at my home in Virginia, I was struck by the appearance on the water of circles of iridescent colors such as may be seen on any wet street where oil has been dropped from an automobile. "Gee-whiz!" said I to myself. "Did I come up here from Texas to forget there was such a thing as oil only to find oil springs on my own place?" I immediately cut me a stick long enough to reach the colored patches and proceeded to test them. I found indeed that while the colors and circles were quite similar to those of oil they did not have the flow of oil circles, but when stirred they broke into angular portions which did not readily reunite. It was simply a scum of organic or ferruginous matter—and so I was spared the harassing trouble of opening up a new oil field.

Oil as it occurs in nature is in reality a series of organic substances, beginning with light gases and passing downward through oils of various gravities to asphalt, asphaltine and carbon. It usually occurs as a mixture of several grades of these oils and gases.

The questions as to the origin of oil and its manner of formation have been widely discussed without any final agreement having been reached as to either.

We know that volcanoes emit gases of the oil series and that some of these are condensed into oil, but there is not sufficient of this to be of commercial importance. By far the greater part is derived from the decomposition of certain animal and vegetable matters under special conditions. At times this decomposition takes place in the open air and the resulting oil is carried by water and absorbed by sand beds. At others, it seems that the decomposition, in part at least, takes place on the bottoms of very salty lakes or seas, such as the Dead Sea, but the alteration may also take place from remains buried in sediments laid down in salt-water. Apparently salt is a necessary adjunct to the generation of oil, and in some districts the oil is found in direct connection with the salt.

Thus, in the Gulf Coast region of Texas, almost every oil field is located on the apex or flanks of a salt dome.

These domes are the peaks of deeply buried mountain ranges, and the oil and gas have in some manner found their way up the slopes of these ridges and peaks to porous beds along their flanks or on their tops, where the oil is gathered in pools under considerable pressure—hundreds of pounds to the square inch—and held until reached by the drill, when it bursts out as gushers. A part of this pressure is from the included gases, but by far the larger part is hydrostatic and due to the accompanying salt-water.

The salt masses of these domes sometimes reach, nearly or quite, the surface of the ground, as at Jefferson Island in Louisiana. At others the salt lies at depths varying from a hundred feet to two thousand feet or more. Some of these domes afford great mines of rock salt. I was in one a few weeks ago where the salt was being mined from a depth of over five hundred feet, and boring had proved the salt to be in a solid bed three thousand feet below this and at least a mile in diameter.

[1] Formerly state geologist of Texas and later consulting geologist, vice-president and general manager of the oil properties of the Southern Pacific Company.

A part of the decomposition of organic matter which results in the formation of oil is believed to be bacterial. In California, much of the oil is derived from minute animalculae, while elsewhere it seems to be from the remains of plants.

Oil occurs in rocks of all geologic ages and in almost every quarter of the globe, but in many of these it proves to be in too small quantities for satisfactory development. For instance, there are places where the oil occurs impregnating beds of rock hundreds of feet in thickness and extending over thousands of square miles and where the aggregate of the enclosed oil is far greater than the total production of the larger fields—and yet there is no available oil at all. It is simply disseminated through the rock material and can not be separated. It is only where a number of favorable conditions combine that we find the oil pools which yield such stores of wealth and romance. Fortunately for the world there are many such places. In all these cases the oil occurs as actual oil.

Of late there has been considerable talk of the vast deposits of oil shale and the great amounts of oil that can possibly be recovered from them. There is no question as to the existence of immense deposits of these shales in the Rocky Mountain region and on the west coast as well as in Kentucky and other more eastern states. But in none of these does the oil occur as actual oil but rather as potential oil—a substance known as keragin, which is allied to the fats and yields oil when subjected to destructive distillation. Other shales carry resins which similarly yield oil when properly distilled. The possibility of producing oil from these shales commercially is a problem of the future.

From earliest times oil and gas have been known and used in eastern countries. Gas springs and sipes were used by ancient priests to keep perpetual fires on their altars or shrines, and asphalt was used as mortar in the walls of Babylon and elsewhere. History records many uses of the oil in Persia, China and other regions of the east—and it was used medicinally by the American Indians long before the discovery of America.

Its real utilization, however, began with the drilling of the Drake well in Pennsylvania less than seventy years ago, since which time the oil business has grown into one of the greatest industries of the world.

So great was the value of this industry to Pennsylvania that the Geological Survey, under Professor Lesley, made a special study of it and by their work greatly aided in its extension. One of the geologists engaged in this work was my friend, Dr. I. C. White, who decided that as the rocks and rock conditions of the Pennsylvania oil fields could be traced into West Virginia, he could see no reason why the oil pools should not also be found there.

This was the earliest application of strictly geological work to oil field investigation. He found little encouragement among the people who should have been most interested, and finally decided to venture the drilling of a well or wells to prove or disprove his theory. He found the oil and made West Virginia a famous oil and gas producer, and in addition he secured for himself not only a considerable fortune in money but a most enviable reputation as an oil geologist. It was through my personal knowledge of him and his work that I began my investigations in Texas, California and Mexico along the same lines.

The search for oil is really a most entrancing occupation, but possibly it is the enthusiast who knows least about the game who gets the greatest thrill out of it, although there is usually a plenty of excitement for everybody.

It is a great gamble, a game fraught with continual surprises. Many, in fact most, of these surprises prove to be bitter disappointments, resulting as they

do in the loss of time and of much money from drilling and finding only a dry hole. Occasionally oil is struck by the more fortunate and in such large quantities as to bring a rapid rise to wealth unsurpassed by any other calling in the world. It is these occasional yields of great fortunes which are usually heralded abroad, while the losers are quickly forgotten. But even those who fail, time and time again, seem infected with a growing optimism which will not let them acknowledge defeat—and sometimes a change of luck puts them in the ranks of the plutocrats. I might say also that at the present time the oil game is a very expensive one. While our company has had wells costing only three to five thousand dollars that quickly paid for themselves in only a day or two, yet on the other hand we have had wells that cost from a hundred thousand to two hundred thousand dollars that never produced a drop of oil.

I suppose that the average well in the Los Angeles district to-day costs fifty thousand or more. This is not a game of penny ante in which a man of moderate means can afford to indulge.

The discovery of oil is usually due to the occurrence on the surface of the earth or water, of gas blows or oil sipes, which may show as simple colorings and slight flows of oil, or which may expand into pools or even into lakes. In other words, oil very frequently, but not always, discovers itself. Once it is known to exist in a region, however, there are many minor signs which indicate its probable occurrence at different places in the vicinity, such as salt or sulphur water in wells, what is known as paraffine dirt, slight arching or doming of the overlying rock material, etc.; and it is to all these that the searcher for oil gives his attention. Although the surface indications show the presence of oil, close geological study is necessary to determine just how and in what connection the oil occurs, so that it can be traced from these surface deposits to the hidden pools which yield the principal supplies. The geologist also uses the knowledge he gains from such study to find other and similar pools where there are no such surface indications, and sometimes hundreds of miles from the original locality of his work. At present, too, it is the geologist who really directs the drilling and who, through recently improved methods of research, is able to say exactly in what beds the oils of different localities occur and to advise the driller as he passes through the overlying beds just exactly where he is, how these beds are related to the oil and how soon the oil will be struck.

It may be of interest to tell how such an extraordinary thing is possible that we can recognize a bed of clay or sand or rock from a mere handful of fragments brought up by the drill from thousands of feet below the surface when similar beds may not be found on the surface for a distance of many miles. In regions where the harder rocks prevail, such as limestones and sandstones, it is possible to recognize some of them by their composition, color or texture, or by such fragmentary fossils as they may contain; but in our Gulf region, where the materials are uncompacted clays and sands and fossils are very scarce, this was practically impossible until I devised and put in operation an entirely new method of examination about five years ago.

The most of the sands and clays which we encounter in this region were deposited in the salt and brackish waters of ocean, gulf or bay. In all such waters there is usually a wealth of living forms of very minute organisms, which we know as foraminifera. These foraminifera, although too small to be seen clearly by the naked eye, have tests or shells which on the death of the organism fall to the bottom and are buried in the deposits of silt or clay or sand brought out by the rivers from the land. These organisms are as varied as those

of the molluscan kingdom and like them differ for each separate geologic horizon. In fact, each species and variety has its own peculiar shell, many of which are most beautifully marked. All these characteristics are clearly distinguishable under microscopic study.

My idea was that these minute shells might aid us in our studies of oil geology. I therefore at once had collections made from the outcrops of typical materials of all the beds of our region and had these studied for their fossils and foraminifera in connection with material from wells we were then drilling.

The process of handling the material is that it is first soaked and lixiviated until all the clay is washed out and nothing left but the sand and other minute mineral grains and the foraminifera. The forams are then separated by examination under good microscopes. A study of them and comparison with type collections tell exactly what beds they come from. In this way it is possible while drilling an oil well to keep an exact log of the different horizons through which the drill is passing, even though many thousands of feet below the surface of the earth. Hence there has been demonstrated the remarkable fact that a geological study can tell with certainty exactly when oil is to be struck. In fact, this method has been a most successful one in the drilling of wells along the Gulf coast, Texas, Louisiana and Mexico.

To-day also the geologist has the advantage of certain forms of physical apparatus which are of vast assistance in the search for oil in certain districts: the torsion balance, which measures the difference in gravitational effects of the underground beds; the seismograph, which measures the differences in the rate of transmission of shocks from explosions of dynamite through the beds, and the magnetometer, which measures the speed of electrical transmissions through them. By the use of these instruments, unsuspected domes and oil pools are being discovered in low-lying perfectly flat portions of the Gulf coast.

As opposed to the slow but perfected methods of the geologist, we have the rapid work of the wigglestick artist. Those gifted men who, with instruments varying from a simple forked stick of green peach, apple or willow to more complicated forms of apparatus of their own invention, are able, as they believe, to predict the presence of oil and also to give the exact depths at which the drill will reach it. Strange to say, however, their boasted skill seldom yields them the rich returns which should come from successful predictions of this kind.

I have only known of two real successes by wigglestick artists. One of these men succeeded because oil really underlay the whole tract on which he was operating and any well put down would have reached it. He made a fortune out of his first venture, but alas, spent much of it in vain attempts to find oil on other properties where his instrument always predicted it—but the oil perversely refused to be discovered.

This man, a burly doctor, had for his partner a very small man weighing little, if any, over a hundred pounds. After their initial success on the Humble dome they first leased and then bought a league of land (four thousand acres) lying east of the dome because their wigglestick indicated oil at places on the tract. They sunk part of the money already made trying to get oil on the league but without success, and finally they deserted it for pastures new. Later they subdivided the league and leased it to other oil companies. On one of these leases, which was not specially favored by the wigglestick, Cullinan brought in a well which produced a million barrels of oil in ninety days. This gigantic well naturally caused others to drill, with the result that the royalties made the original owners very wealthy. Of course, all the credit for the huge success was given to the wigglestick.

The other success came to a poor Frenchman whose apparatus seems to have had some real merit in that he actually did foretell in three or four wells not only the depths but the character of the oil which would be found. One of the owners kept me advised during the drilling and was very positive that this was true. Unfortunately for the Frenchman, he was working without a written agreement. The owners took advantage of this and refused absolutely to give him any interest in his discoveries or to pay him for his work, which proved to be worth millions to them. He died of a broken heart. A twenty-seven story office building erected in the south by the widow of one of those he made rich is in reality a monument to the Frenchman!

Still another method of finding oil is the hunch. One of our luckiest operators told me this tale of how he located one of the famous fields of north Texas. He said he felt a hunch that there must be oil west of Fort Worth and just south of Red River, so he and his brother with one or two others started to look for it. They traveled westward for several days examining the country, and finally not having seen anything that suited their fancy, they started back. That evening as it was getting dark a black cat crossed the road just in front of them. "There," cried my friend, "there is my oil field."

They marked the place, went on into the nearest town for the night, and next day went back and made their leases—and soon brought in a field that after many years is still producing.

But how about the thousands of other hunches that did not pan out?

And then some of our good friends were always so anxious to help us in the finding of oil! One man brought us word of a well that had been drilled on the west coast of Mexico, saying he had been there and had seen the oil. I started a man from San Francisco by steamer for the nearest Mexican port. From there he had to take a sailboat down the coast and go inland by mule train. He found the well and the oil—but somehow the oil did not look exactly right to him. So he spent a few days searching the hills and finally ran upon a lot of tin cans that had held lubricating oil, and so solved the origin of the oil in that well.

Another report of an excellent oil sipe was brought us by some one who had found it on the banks of a creek north of Spindle Top. I sent out to examine it at once. My assistant found it easily and it was a real sipe of good oil, but he could not see exactly why there could be a sipe at that particular place, so he concluded to do a little digging. He did not get on very far before he found a small pipe, and following the pipe he found a barrel of real Spindle Top oil buried in the creek bank high enough to let the oil flow slowly to the wonderful sipe—and that was that. Many such plants have been carefully and deliberately arranged with a view to giving enhanced oil values to ordinary farm lands.

As I have stated, several of the great oil fields of California, Texas, Oklahoma and Mexico actually discovered themselves. In California the asphalt deposits of Rancho La Brea, near Los Angeles, itself a marvelous graveyard of prehistoric animals and birds, the extensive asphaltic sand beds of Ventura and other coastal countries, the asphalt beds and oil and gas sipes extending up the San Joaquin valley from Sunset and McKittrick to Coalinga, all proved the existence of oil before we ever began to drill for it. We knew for certain that the oil was there somewhere, and our work was to find just where it was and how it occurred. It was my great pleasure to have done this most successfully for the San Joaquin Valley region where the great bulk of the Southern Pacific lands were located and to have been one of the principal instruments in this development. My work

and that of my assistants outlined and developed much of the oil-bearing territory which is now pouring out its streams of black gold in the Los Angeles district and around Ventura. In fact, it was the possibilities of this area, as I presented them to Mr. Harriman in the year 1903, that caused the conversion of all Southern Pacific locomotives from coal burners to oil burners.

In Texas, the oil and gas sipes at Sour Lake, Saratoga, Batson and elsewhere were well known and attempts at utilization made many years before the oil boom. As early as the year 1892, drilling was in operation at Spindle Top in order to reach the oil believed to be there. As state geologist I cooperated with them and had an observer located at the well, which, however, could not be drilled deep enough because the method used, that of the old percussion drill, was not suitable.

One Monday morning in January, 1901, I reached El Paso on a trip from San Francisco to Houston. The morning papers were ablaze with the news of a great oil well brought in the day before at Spindle Top. Trains were slow in those days and it was Tuesday night before I reached Houston. Early Wednesday morning I was at Spindle Top to see the wonder of the world—as it was then thought to be. It really was a remarkably great well and marked the beginning of an epoch in the history of the Gulf coast and of Oklahoma. Captain Lucas, by the use of the rotary system of well-drilling, had succeeded where the previous operators had failed.

A scramble for wealth was started that was unequaled even by the great rushes of the Pacific slope.

In Oklahoma, I had called attention to the asphalt deposits near Ardmore as early as 1894 and had made an effort to secure their development. Others had pointed to similar deposits elsewhere in the territory (as it was then). As a natural result, the later successful exploitation of the Texas fields brought their development also.

In 1888, my assistant and friend, Mr. Josiah Owen, one of the most competent geologists I have ever known, made a trip into the Tampico region to examine the asphalt lakes of Mexico. Ten years later I made a strong effort to induce Mr. Huntington to look into the matter and develop the oil, but he thought the deposits were too far from his railroad lines to interest him. Not long after, Mr. Doheny went to Ebano and found some heavy oil. In 1907 or 1908, Mr. Harriman wired me to look into it and we did so. The result of our work and that of other companies who followed us, influenced in part at least by our action, developed phenomenal fields in that region and produced one well which as nearly as could be measured yielded oil at the rate of 265,000 barrels daily, so far as I am informed the very largest yield in the world's history.

Now it must be remembered that all this great pioneering work was done, and all these thousands and thousands of miles were traveled, before there were any automobiles, and when, outside of the railroads, which had a way of going anywhere but where we wanted to go, we had to depend on horses and wagons; when fifty miles a day was an outside limit and thirty-five a fine average. And yet even this had its great advantages, and we certainly did closer work than our automobile partners do nowadays. One of the best observers in South Texas said to me a few days after a new dome had been discovered—at least it was new to them though not to me: "You early workers certainly had the advantage over us in travelling by wagon. I have gone over that dome a hundred times at thirty-five miles an hour and never suspected it—while had I gone in a wagon I see now I could not have failed to know it was a dome." So our slow locomotion was not so bad after all.

When I went to California in 1899, the city oil field in Los Angeles was well developed, there were a number of wells at McKittrick and others between Los Angeles and Santa Barbara, but the total production was rather limited. Outside a publication or two by the state mineralogist, there was very little information regarding the oil geology, and neither then nor for many years afterward did any company except the Southern Pacific pay any real attention to this side of the business.

My idea was that geology should be made the basis of all real oil development, and in organizing the work in California I always planned with that end in view. The geological method proved to be a great success from the very start and while the history of the opening up and development of its oil lands by the Southern Pacific had nothing of the spectacular about it we made a steady advance and the results to the Southern Pacific ran into hundreds of millions of dollars. This great financial success, which was clearly the result of our geological work, caused geological methods to be used by more and more oil companies until to-day the geologist is an absolute necessity with all of them. And this result is equally true in all the more recent fields.

Along the Gulf coast on the contrary, we were anything but quiet. At times, it was more like a stampede. Wells were drilled at any old place, with or without reason, and sometimes, even when there was no apparent reason, they found oil—wildcats of the wildest breed—and whenever there was a sign of oil, land prices soared and people fell all over themselves trying to purchase or lease. Companies were formed and stock sold broadcast over the United States on any basis or no basis. On Spindle Top, lots twenty by twenty were sold at $2,000 each and upward, a total of over $200,000 per acre. Needless to say many of these never paid for themselves, although others were cheap at the price. We had one or two of these. The difference was not in the actual oil value of the ground, but in handling it so as to get your share of the value as soon as possible. It was a great and mad scramble. Nevertheless, to have gone through it and to have experienced the exhilaration and tingle of excitement, to have breathed the air surcharged with the gambling urge, to have seen the really great deeds that were done, to have known the men who did them and at the same time to have been an integral part of it all, was to have really lived.

The Spindle Top field had a total area of only four hundred acres, yet on this small area there were thousands of wells drilled, and it has produced more than seventy million barrels of oil. While it was commonly spoken of as "the hill," the rise from the surrounding level prairies was so slight that it was scarcely to be noticed by an ordinary observer, and during its early development it was frequently surrounded by seas of mud, which at times were all but impassable. In fact, this was the case with many of the coastal oil fields—the finding of a new field seemed to be the signal for regular downpours of rain with the result that the wagons and teams stirred the stiff black prairie soil into regular quagmires.

The early production at Spindle Top was so great and the sale so restricted that the price fell to as low as five and six cents a barrel. With oil at this price, it was not considered such a venial sin to appropriate some of what was really your neighbor's. The oil flowed from the wells into pits and was pumped from them through pipe lines into large steel tanks located at some distance from the field. One morning going over on the train one of the large operators told me in great glee, "Do you know I have cut in on Higgins' pipe line and every time he pumps to his tanks he pumps part of his oil to mine." And this was by no means an exceptional occurrence.

Later when oil became more valuable the scene was changed and I remember we sat up two nights with shotguns waiting for the man who had cut in on one of our lines to come and turn the valve. He did not come—so we broke the connection and let it go at that.

As time went on and wells multiplied at Spindle Top the derricks in some parts of the field were so thick that they actually touched. And then came sweeping fires which wiped them out by the score!

Then also came the deadly gas which killed numbers of workmen and blinded many of the others totally or temporarily. I remember one night the gas from one of the wells in the Batson field killed all the men who were sleeping in a bunk house nearly half a mile away—and two or three days later when I had occasion to go that way, my companion and I, although we thought we were giving it wide enough berth, both had our eyes affected by it. Fortunately this gas only occurred in two or three fields and gradually died out in them.

As the supply of oil decreased at Spindle Top it ceased to gush or flow naturally so it had to be pumped and as the months sped by the production grew gradually less until finally salt-water began to make its appearance and one by one the wells were abandoned and the field was turned over to small operators or strippers. In this brief story of Spindle Top, I have given you the story of all oil fields. They come in with a rush, rise to their culmination and then decline and are finally flooded with salt-water.

When the salt-water first came into the Spindle Top wells in quantity some of the folks insisted that the Standard Oil Company were pumping it in from the gulf in order to destroy the field. It gradually destroyed the field all right, but the sin was one from which the Standard Oil Company could claim immunity.

The history of Spindle Top was repeated in field after field on the coastal region of Texas and as the supply of oil decreased there, attention was directed to Oklahoma and north Texas which had similar experiences with great yields of oil as the years passed one by one.

Thus the game has gone on in this region for twenty-five years, new fields taking the place of old, new players chipping in in place of those who have dropped out, colossal fortunes being made and lost. From present appearances this game is likely to continue a full lifetime yet. And there are always other fields! Do you wonder it has its devotees?

The principal holding of the Southern Pacific Company in south Texas was the Saratoga field in the heart of the Big Thicket, twelve miles north of Sour Lake, from which point we had to drive by team. When we first took over the property, there were a number of nesters or squatters on it who made their living raising razorback hogs and hunting the deer and bear that were so plentiful in the thicket. They notified us at once that if we attempted to develop the property our rigs would be burned and we would be worried in every possible way. For years I had had as my assistant Professor Cummins, a Methodist preacher and a good geologist. I called him in and told him I was making him manager of the Saratoga field and that his job was primarily to get rid of all the nesters in a friendly way and see that we had no trouble with them. Within a few months every one had either moved away or was working for us and some of their children are still in our employ.

When we bought the property there were two or three lots on the inside we could not get possession of. A little later a noted gunman who lived at Korentz, some twelve miles east, let it be known that he was going to put up a saloon on one of these lots if he had to do it at the end of his gun. Finally he

came to Saratoga, and when Professor Cummins heard of his arrival he hunted him up. After introductions Professor Cummins said to him: "I understand that you have made your boast that you are going to put a saloon here if you have to do it at the end of a gun. Now I want to warn you that if you attempt anything of the kind, you want to be mighty sure of which end of the gun *you* are at." The professor was an old Indian fighter among his many side lines, and I suppose his manner carried conviction as to his meaning. Anyway the man soon calmed down and told him that if he would consent to the saloon he would promise that it should never be rough house in any way. So it was put there and the man was the professor's firm backer from that time on, so that once during a strike when threats were made against Cummins the saloon owner buckled on his guns and sent the strikers word that it was his fight—and it stopped.

One January day in the early history of the field the president of the company and I drove over to inspect the operations. It began to rain in the afternoon, so we decided to spend the night at what was called a hotel. It transpired that there was only one vacant room and one bed, but it was that or nothing. When we finally got to bed we found it already abundantly tenanted and, as if that were not enough, the storm broke again with a play of lightning and thunder and a deluge of rain that contributed to the miseries of the night.

Next morning we found that we could not get away until the creeks ran down. Our scouts said they would be all right by eleven o'clock anyway, so we started out at that time with a cold norther blowing. When we came to the first creek, it looked pretty wide, but the driver said he could make it all right, although the water might come up into the carriage. So we took our grips out from under the seat and stood on the doors holding the grips high enough to escape the water. We got through very nicely. The horses had to swim a short way and we were wet to the knees, but congratulated ourselves on getting off so well. We dried the carriage as well as we could, put our baggage back under the seat and started on our way. The next creek was not nearly so wide and looked all right, so we started bravely in. The horses suddenly gave a lurch and a spring and before we could catch our breath we found ourselves still sitting on the seat but with the water of the creek up to our arm pits —and cold! We still had six miles to drive to Sour Lake and nothing dry to put on when we got there. However, the hotel man gave us a big room and a big fire before which we basked *au naturel* while our garments and belongings dried.

Such incidents as these were regarded as simply part of the game and added zest to its pursuit.

There is, however, another side to the oil game which is not so pleasant to tell about. As long as men are men the successful man will be the mark of those less fortunate and greed is ever to the fore.

My own experience is that of a scientist and a manager of fairly large producing companies which had only a limited sphere of operations. But this gave me full opportunity to see the bad side of the game. I have seen the bitter contests of smaller companies, fighting for their lives, battered and held down by those of greater power who had or could control facilities without which other producers could not market their oil profitably. I have seen the employees of these larger companies use every means to prevent their competitors from completing wells. I have had them actually pay drillers who were working on my wells to hold back my work until they could complete their wells and so get the flush production, and also have had them, in the absence of our men, fill a well with junk so that we had to abandon it after

spending over twenty thousand dollars on it. I have seen great contests for control between the greater companies in a field where most ruthless methods were at times employed—but of late years it has proved more profitable to use the merger and so we have had less of this. Still, strong-arm methods are not entirely wanting even now!

What is true in our individual fields is just as true of the world at large. The control of the oil fields of Rumania, of Mosul in Turkey and Baku in Russia were undoubtedly large factors in the great world war. And these are figuring strongly to-day in the realignment of European politics. Thus the mandate for Iraq which was given to Great Britain covers the control of the Mosul oil field, and this was done over the protest of the Turks.

Germany is striving for control of Baku and it is stated that she has contracts with the Soviet government which will help her acquire it, and Rumania is largely given over to outside control.

To the uninformed there might not appear anything very wrong in this, but it must be remembered that for years before the war these various fields were in possession of and operated by private owners and that this new governmental control changes all this and practically cancels the original private rights in favor of those approved by later governments.

Our own present trouble with Mexico is largely because of the oil question and grows out of her effort to prevent the depletion of her oil fields by foreigners.

It is true that many of us went into Mexico and acquired our lands and produced and shipped our oil in strict accordance with the Mexican law. But there were many others who did not and some who even used their money to debauch the people and the courts in order to attain their ends. To illustrate: In a trial for ownership of a certain tract of oil land, the Supreme Court awarded it to us and ordered the local judge to put us in possession. Our opponent bought the local judge and put private guards on the property to prevent our getting it. Later we got the matter into the court again and before a judge whose probity was acknowledged everywhere. On the trial we had the law and evidence fully in our favor and expected an immediate decision that way. The decision, however, was not made until the following day and, strange to say, was against us. Our lawyer called on the judge and asked his reasons. The judge pulled open his desk and showed a big roll of money. "My God! man," he said, "what else could I do? They gave me 7,000 pesos." When this fact reached Mexico City the judge was deposed and the head of the company giving the bribe was called before the president, who told him that too many reports had reached him of such practice by his company and that it had to stop, and that he must leave Mexico at once and not return under penalty of immediate arrest.

Many other ways were used to get around the Mexican laws and the actions of some of the companies were notorious. The Mexican government seized this and similar wrongful acts perpetrated by or attributed to foreign oil companies as the basis for the claim that the country was being robbed by the foreigners. They then proceeded to enact laws ostensibly to correct these evils, but which in reality seem to be intended as confiscatory and to force the foreigner to turn his properties over to Mexicans or the Mexican government.

All the world over, therefore, oil is a game, a very great and at times a highly remunerative game, but, I am sorry to say, it is not always played fairly either by the individuals, the corporations or the governments.

THE CONTROL OF CRIME

By Dr. EDGAR A. DOLL

THE TRAINING SCHOOL AT VINELAND, NEW JERSEY

FEW questions of national welfare have caused such widespread discussion as that of the control of crime. But probably no question of equal importance has developed more confusion of thought and action. Positive statements from all quarters of public interest leave the ordinary citizen in utter uncertainty regarding the most effective measures to be taken toward wiping out what has widely been termed "our national disgrace." Most of the alarmists recognize only specific causes of crime and ingenuously advocate panacea methods of prevention. But the real difficulty, and yet the one which seems least often emphasized, is that crime is caused by an intricate complex of related influences and that the control of crime requires intelligent cooperative effort.

Thus some find *the* cause of crime in the automobile, the "movies," the dime novel, the dance hall, the broken home, the un-Americanized foreign-born. Others believe the cause lies farther back, in the "fence," commercialized vice, the master-mind, the "higher-up," official corruption, and such. Still others claim that crime is caused by human weaknesses in the criminals themselves, such as feeble-mindedness, insanity, warped personality, uncontrolled appetites, and the like. Likewise inadequate law enforcement, obsolete criminal laws, weak administration of criminal justice, loopholes in judicial procedures, abuses of judicial discretion, unrestricted release of habitual criminals after perfunctory sentences impress many observers as responsible for widespread criminality.

There can be no doubt that all these and similar influences are potent causes of crime. But how do they operate in specific instances? The public is seriously uninformed if it still believes in Lombroso's "criminal man" as a prototype for all criminals. In the jails and prisons of to-day we see plenty of human frailty but not many "instinctive criminals." Likewise the public, lay or professional, is curiously naïve when it accepts such simple social explanations of crime as are specific to our day and age. Was crime less before we had movies? Did the automobile produce crime as a new social phenomenon or did it merely give crime a new *modus operandi*? Was there no robbery before the "fence" was built up or is the "fence" merely a new organization for robber barons and poachers? Crime has always attended the looser forms of public recreation. Official corruption is as old as officialdom. Poverty, vice, personal excesses, prodigal sons, wayward daughters are all as old as history. Public indifference is as old as society.

It is a social axiom that a specific crime requires both a person and a situation. It is a psychological axiom that human nature does not change, although new environments may bring new forms of self-expression. Appetite, passion, ambition, dishonesty, cupidity, indolence, emotional instability, weakness of intellect and of will are some of the human traits which, *acting always in combination* with such social situations as arise from poverty, oppression, illicit association, unwholesome recreation, inadequate protection, display, license, corruption and indifference, produce specific criminal acts. The potentially

criminal person and the potentially criminal situation each requires the other before crime can occur. The nature of the crime depends somewhat on both. In some degree this combination of human and social circumstances is fortuitous. In general, the criminally inclined person capitalizes his criminal opportunities and the upright citizen avoids temptation. But just as there are many degrees of criminals, from the short-weight grocer to the embezzler, so there are many degrees of criminal opportunity from the untested scales to the careless handling of the bank's millions.

When we accept these elementary principles we shall be on a new road to intelligent thought in this matter of crime prevention. Our present classifications of crime are based on the social acts themselves—murder, arson, rape, robbery, assault, fraud, and so on through the list. We are only recently developing any adequate classification of criminals, as casual or habitual, normal or subnormal, stable or unstable, sane or insane. The human disposition of the individual is the predisposing factor, and the social situation is the precipitating factor in determining the specific character of the criminal act. *Both are essential* in studying the causes of crime and the consequent methods of prevention.

It ought not to be necessary to call attention to the large body of authentic literature dealing with crime from a technical and professional point of view involving all the relationships such as have been mentioned. Even a casual review of such publications as are contained in the Modern Criminal Science Series[1] is sufficient to give such a fundamental orientation. The most modern scientific theory of crime is that of Ferri and is more than fifty years old. Ferri states that:

> Crime is the result of manifold causes, which, although found always linked into an intricate network, can be detected, however, by means of careful study.

And further he says:

> Crime is a phenomenon of complex origin and the result of biological, physical, and social conditions. *Certainly, the dominant influence of this or that factor determines the biosociologic variety of the criminal, but there is no doubt that every crime and every criminal is always the product of the simultaneous action of biological, physical and social conditions.*[2]

More than fifty years ago the complex causes of crimes and the methods of their prevention were embodied in a declaration of principles promulgated by the American Prison Association. In the meantime a general sentiment has developed throughout the country that crime is on the increase, and this has created an insistent demand for more definite and more cooperative action. Various crime commissions and a number of local conferences have suggested programs of action.

In formulating such a program, designed to promote the cooperation of all agencies interested in the reduction of crime, it is obvious that since crime is the result of the interaction of men to their environment, and since the causes for those acts which we call criminal are found both in the individual and in his environment, therefore no program of crime prevention can be considered adequate which does not include a comprehensive consideration of human characteristics and social forces as they react upon each other.

Such a preliminary analysis of the situation reveals at least seven major groups of conditions within which most of the influences related to crime can be encompassed. The enumeration of these influences, with some illustrative detail,

[1] Published under the auspices of the American Institute of Criminal Law and Criminology, Little, Brown & Co., Boston.

[2] Italics ours.

constitutes in itself a suggestive program for cooperative action. The need for further detail on each of these influences will be obvious.

(1) *Statistics.* The current interest in the reduction of crime is largely due to the popular belief that crime is on the increase. This belief is no doubt caused by the large number of sensational crimes and the widespread dramatic publicity which attends them. Certainly the increases in population and in complexity of economic and social organization might be expected to produce an increase in crime in spite of reasonably successful efforts toward crime prevention. Certainly also the improved facilities for news gathering and publication give the public a much wider knowledge of the seriousness of crime as a national menace. But what are the facts? Is crime actually on the increase? Are there significant changes in the relative frequencies of the different types of crime? Are there significant differences from a statistical point of view in the nature of crime and criminals? Are the available statistics reliable? Are they comparable? In other words, what are the basic facts regarding the present crime situation as to such items as: crimes actually committed, criminals apprehended, convictions secured, punishments meted out and criminals rehabilitated. Do criminals actually graduate from the streets to the gang, from the gang to the jail, from the jail to the reformatory, from the reformatory to the prison, and from the prison to a life of habitual criminality? What do we know statistically about recidivism? Obviously, any intelligent analysis of crime prevention must be founded upon accurate knowledge of the actual facts in order that we may "apply the oil to where the squeak is." At present most public statements can not be substantiated by reliable figures, for the statistical data are hopelessly incomplete and incomparable

(2) *Predisposing conditions.* Crime obviously arises initially through a number of predisposing conditions, material, environmental and individual. In certain more or less fortuitous combination these produce precipitating influences and reduce potential criminals to overt offenders. Among these predisposing influences may be mentioned such details as unsegregated mental defectives, unprotected minors, bad housing conditions, inadequate public health supervision, uncontrolled drug and liquor traffic, inadequate supervision of public recreations (movies, dance halls, road houses, night clubs), broken homes, low social standards, poverty and economic handicap, extravagant taste, unreasonable ambition, and such others as are epitomized in the time-worn expression "wine, women and song." What do we know and what can we do about all these conditions as causes of crime?

(3) *Opportunity for crime.* Somewhat analogous to these predisposing conditions are those influences which create precipitating conditions. Garofalo calls this the opportunity for crime. There are "natural" crimes arising from instinctive or emotional causes and "artificial" crimes arising from social institutions or political conditions. There are crimes against chastity, against honor, against the person, against property and against modern laws. We may mention such details as inadequate protection of person or property, provoking or careless display of valuable or personal effects, abuses of insurance and bonding, careless trust of strangers, advantages taken of political power or of business conditions. There is also much ignorance and disregard of laws making possible even unintentional misdemeanors or felonies.

(4) *Criminal law.* Many authorities

believe that the continuance of obsolete laws or of indefinite laws or of unpopular laws creates situations which engender disrespect for laws in general with consequent social disorder. There is also much antiquated legislation which obstructs police and court procedures, such as rules of evidence, technicalities, systems of appeal, unequal or unreasonable penalties which aggravate rather than ameliorate the control of crime. Other laws may be ineffectual, nonexistent or subject to abuse, such as those providing for adequate systems of probation, pardon and parole, indeterminate sentence, restitution following criminal offenses, control of the criminal "fence," control of habitual criminals, control of deadly weapons and similar items. We must reckon with existing abuses in the selection and control of juries and in the whole machinery of our judicial system, such as rules governing expert testimony, loopholes in prosecution, judicial discretion in sentence, probation, place of commitment, fines *vs.* imprisonment, and so on through a long chapter. In this whole group of influences we are concerned especially with the administration of criminal justice and the need for honest and courageous application of such legal procedures as do exist and might be more effectively employed.

(5) *Law enforcement.* Under this heading are those influences relating to the speedy apprehension of criminals, including adequate policing, vigorous pursuit and detection of criminals, methods of criminal identification, cooperation of detection and policing agencies as between cities, counties and states, the centralization of policing authority and methods for the exchange of criminal information. If there is one thing we are sure of in experience it is the fact that speed and certainty of punishment and not severity are the greatest deterrents to crime.

(6) *Punishment and correction.* This group of influences relates to problems in the administration of penal institutions and methods of preparing prisoners for release, such as disciplinary conditions in jails and in penal and reformatory institutions, sanitary conditions, systems for the intelligent classification of prisoners according to mental, physical and social tendencies, facilities for correctional treatment (medical, moral, industrial and educational) following such classification, industrial employment and training of prisoners, provision for self-government, methods of release and so on. Great progress has recently been made in controlling this group of factors.

(7) *Rehabilitation of offenders.* This group includes problems of probation and parole, including methods of determining suitability for release, means for restoring released offenders to sound industrial and social standing, adequate correlation between the penal institution and the community, adequate systems of probation and parole supervision, and so on. The more widespread use of scientific methods in studying the individual convict before release is one of the most significant advances in modern penology.

It is obvious that at least these manifold factors must be studied in further detail with reference to their interrelationships before we can successfully control crime in this country. Vigorous effort can accomplish something in any or all of the above divisions and we must not relinquish our endeavors to advance each portion of the above program separately as well as coordinately. But it takes little imagination to see the need for immediate national coordination of all the many agencies dealing with the problem all along the line, from the initial social situation which predisposes individuals toward crime through all the many steps prior to the successful

rehabilitation of convicted offenders. To promote this coordination it will be necessary to harmonize the numerous influences involved, urging each interested group to carry its own responsibility into action rather than to point to the breakdown of other agencies concerned and also to cooperate fully with such agencies. Our principal need is an intelligent program of prevention. But for crimes that can not be prevented a program of correctional treatment is equally important.

The practicability of such cooperation is effectively witnessed by the recent conference called at Washington by the National Crime Commission, which successfully brought together a large number of interests from the above-mentioned fields and undoubtedly promoted a much more intelligent understanding of the many problems involved as well as a larger and more vigorous national interest in the whole question.

How may increased coordination of effort be brought about? How can the numerous agencies concerned with the control of crime support each other and at the same time increase the success of their own efforts in their special fields of endeavor? Obviously such cooperation requires some central correlation. We need publicity, official support and leadership, and these must be imaginative, vigorous and sincere of purpose. Such cooperation must be both local and national, for the character of crime varies with geographical and political conditions.

At present this centralization of effort can best be promoted through the various crime commissions, municipal, state and national. These commissions are or should be conversant with local and general situations. Composed as they are of men of affairs and influence, they are in an excellent position to serve as rallying points for the promotion of such a program as might be subscribed to by all concerned. But while these crime commissions might be expected to advocate the most effective methods of crime prevention, they at present seldom do so because as now composed they do not represent all the interests vitally concerned with the problem. To offset this serious defect these commissions might be enlarged by the appointment of outstanding representatives from all the major interests concerned with crime prevention. Or the crime commissions as at present constituted should appoint advisory committees of representatives from each of the seven fields of interest cited above. These committees acting as advisory groups to the crime commissions could then be instructed by their respective commissions to formulate programs which the commissions could adopt with a reasonable prospect of practical success. The commissions could then utilize the various legislative, administration, business, social and technical resources of the country in a concerted attack on the problem. Then these crime commissions instead of advocating programs obviously narrow, unimaginative or uninformed could promote a program of unified intelligent action supported by the best public and professional thought on the subject and could promote a widespread campaign of publicity designed to stir up that interest on the part of the general public without which no program can be carried into action.

These various crime commissions with an adequate program based on technical advice should then be developed as clearing-houses and as research centers for the collection and dissemination of information and factual material. These clearing-houses by promoting a demand for information relating to criminal statistics, the administration of justice, the conduct of correctional institutions,

methods of community protection, and the like, would have a wholesome effect at once in bringing to a higher level of efficiency the already organized public and private efforts for crime prevention and control. These crime commissions, through fact-finding agencies, and even perhaps with their own research personnel, could analyze and correlate the multiple influences tending toward the production of crime and could evaluate the [illegible] of various efforts toward the reduction of criminals.

Finally, while we insist that crime results from the interaction of men to their environment, there is already a preponderance of evidence which shows that the criminal person is much more important than the criminal situation. We have been a long time learning that the individual tends to create his own environment rather more than he is created by it. Biological forces are relatively permanent, although the form of their social expression is extremely variable. This in itself tends to show man's control of his environment, for he selects and modifies the conditions under which he carries on his existence. Certainly the scientific study of the criminal himself is to-day the most tangible means of dealing with the prevention of crime. This is evident in the fact that most social legislation intended to reduce crime is directed more toward the human factor than toward the social factor. Since Lombroso, and more particularly since the recent advances in the social sciences, we have a new weapon in dealing with criminals which if effectively used would give us instead of him the whip-hand in reducing this menace to our social welfare.

LIKE FATHER LIKE SON-IN-LAW[1]

By Dr. DONALD F. JONES

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

In the movies the policeman's daughter marries the banker's son and—we are led to infer—live happily ever after. This happens so seldom in real life that the plot is always entertaining, and as citizens of a thoroughgoing democracy, where every individual is as good as every other, if he can prove it, we applaud enthusiastically. This enthusiasm may be entirely absent in the rare event occurring in the banker's own family, but even in their disapproval most people feel somewhat apologetic, as if this attitude were contrary to a worthy ideal which should be everywhere upheld.

This way of thinking is founded in part upon the customary rule that people having opposite characters should marry: tall with short, fat with lean, blond with brunette, stolid with vivacious. While we are told that the bringing together of dissimilarity in physical characters and in temperament are conducive to conjugal happiness, let us see what people actually do in this respect.

In the biological journal of statistics, *Biometrika*, there is an article by Professors Pearson and Lee which gives the results of their studies in England on the similarity of married couples with regard to such easily measurable characters as height, span of arms, length of forearm, color of eyes and longevity. Surprising as it may be, they found that husband and wife are more alike, even in these less important qualities, than first cousins. The size measurements were made upon the parents of college students from widely separated districts, and the results are considered not to be affected unduly by marriages occurring within different local races which might show an apparent correlation when none actually existed.

This opportunity for error was also carefully ruled out in their investigation of longevity. In this study the ages were taken from tombstones in two rural communities where the people belonged to the same racial stocks and seldom moved from the community. Data were also taken from the very complete records of the Society of Friends. There is a tendency, which was fully recognized, for the husband and wife to be buried in different localities when their deaths occurred at widely separated intervals, and for that reason the larger differences would not be included in the tabulation. This was borne out by the figures obtained from a London cemetery which showed a much closer agreement in age at death than from the rural communities. Undoubtedly the failure to include the more negative pairs was responsible for this. The authors carefully considered all variable factors which might give a relation not based on similarity in length of life and concluded that there is an assortative mating of people of nearly equal vitality as measured by the life span.

A tendency toward a longer or shorter length of life is definitely inherited, as shown by Professor Pearson and by Dr. Pearl. Long life is an indication of general constitutional strength. It has also been shown that the similarity between husband and wife is greater among the parents of adult children than it is for childless couples, so that the mating of like with like is a factor in fertility and consequently tends to perpetuate itself.

The influences which tend to prevent inter-racial unions involve much more

[1] The data upon which this article is based are given in "Selective Fertilization" in the University of Chicago Science Series published by the University of Chicago Press, 1928.

than physical differences. The whole social inheritance, customs and folkways separate not only races but different political and religious groups as well. Wealth and social position are notable factors in determining conjugal ties; and, since these have some basis in mental ability, inherited intellectual capacity is an important agency in determining the partners in matrimony. Terman's studies on gifted children bear this out. The parents of children which stand high in the intelligence tests are themselves distinctly above the average.

An explanation for this tendency for like to mate with like has been put forward by the behaviorists. The young man in seeking his life partner instinctively chooses a girl who is like his mother, while the young lady considers favorably only those men who are, in some respects at least, similar to her father. Since, as we shall see later, homogamy is a common practice throughout the animal kingdom and a similar situation exists in plants, is it not probable that there is involved here something of a far more biological importance and racial significance than this rather superficial explanation would indicate?

If man is an animal, as biologists insist, the mating instincts of lower forms of life should have interest in this connection. Plants are also bisexual organisms. Is reproduction among them purely a matter of propinquity?

The lowest organisms, if we may judge from the evidence from the single-celled Paramecium, do not mate at random. Each individual not only refuses to mate with members of other species, but successful pairing takes place only when the partners are alike. This is shown by the extensive observations of Professors Pearl and Jennings, of Johns Hopkins, who find a significant correlation in size, the only character that could be measured, in the conjugating pairs of this species.

In another protozoan form, it has been observed that individual members of the same culture differed as much as 14.5 millimeters in length, but no two members of a conjugating pair differed more than 5.5 millimeters. Out of 279 pairs, thirty-five were equal and only seven pairs differed more than 3.5 millimeters.

Going somewhat higher in the animal scale, there is evidence from the mollusks of an assortative mating. The hermaphroditic nudibranch has been carefully studied by Professor Crozier, of Harvard, who observed that in most cases large individuals mated successfully with large, and small individuals with small at various seasons of the year. Two different species of this animal frequent the waters about Bermuda, but they have never been seen to hybridize under natural conditions; and even when confined in small dishes the two species could not be induced to mate.

Among crustaceans and insects the same condition holds. In two similar species of fruit fly, Dr. Sturtevant, of the Carnegie Institution, has noted that the females of either species are far more likely to unite with males of their own species than with those of the other, although the males court females of either species apparently without discrimination.

The results carefully compiled from a few widely separated groups among the lower animals show a definite tendency for similar individuals to take part in reproduction. The situation among the higher animals is indicated by a number of observations taken from Darwin's "Animals and Plants under Domestication." The Alco dog of Mexico dislikes canines of other breeds, and the hairless dog from Paraguay mixes less readily with the European races than the latter do with each other. In Paraguay the native horses which run loose on the plains associate with each other according to color, and horses imported from other districts tend to remain aloof. In Circassia several subraces of the horse

live a free life. They refuse to mingle and cross and will even attack each other.

In England the heavy Lincolnshire and light Norfolk sheep, though bred together, when turned out on pasture separate to a sheep in a short time. On one of the Faroe islands not more than half a mile in diameter, the half-wild native black sheep are said not to have mixed readily with the imported white sheep.

Dark- and light-colored deer which have long been kept together in the forest preserves in England have never been known to mingle. Tame rabbits which had run wild on the island of Porto Santo were kept in a zoological garden and would not mate with any of the tame breeds. The dovecote pigeon seems to have an actual aversion towards the several fancy breeds, and it has been observed that flocks of white and common Chinese geese keep distinct.

The elaborate devices which plants have developed to induce insects to transfer pollen from one flower to another and many other intricate ways in which cross-pollination is brought about make it seem that germinal mixing is favored in these organisms. The phenomenon of self-sterility is also widespread in plant families. Fruit growers have long contended with the failure of many cultivated varieties to set fruit when none but their own pollen is available. They have been forced by costly experience to make careful selection of varieties that are suitable pollinators for each other and in some cases have to grow less desirable kinds solely because they are necessary to insure proper pollination and abundant fruit setting. At the John Innes Horticultural Institute in England there have been grown apple, cherry and plum trees which bloomed freely over the entire tree, yet only certain branches produced fruit, those that were pollinated artificially with compatible varieties. The other branches on the same trees were self-pollinated and were entirely bare of fruit.

These facts have led biologists to believe that outerossing is the natural state of affairs in plants, and have persuaded them that this was physiologically necessary to maintain normal vigor. Recent experiments at the Connecticut Agricultural Experiment Station and elsewhere have shown clearly that in several species of plants there is a clear-cut tendency in the opposite direction—that among different varieties each type is fertilized more readily by its own kind of pollen than by pollen from any other variety.

This was discovered largely by accident. In an experiment to test the immediate effect of cross-pollination upon the chemical composition of the seeds of corn it was desired to have self-pollinated seeds produced upon the same plants. To do this, pollen from two different types of plants was mixed and applied to the protected flowers of both lots of plants which produced the pollen. Advantage was taken of inherited seed characters which differentiated very clearly the self-fertilized and cross-fertilized grains.

In carrying out an experiment of this kind pollen from a variety of corn having yellow, wrinkled seeds was mixed with pollen from a variety having white, smooth seeds. Equal quantities of pollen were taken from each type of plant, placed in a paper bag and thoroughly mixed by shaking. This mixture was applied to the pistillate flowers of both types of plants which had been protected from all other pollen. When mature the self-fertilized and cross-fertilized seeds were quite distinct on each lot of plants, owing to the phenomenon of dominance of yellow over white color and smooth over wrinkled texture. On the yellow, wrinkled variety the cross-fertilized smooth seeds showed up very plainly among the wrinkled self-fertilized seeds. On the white, smooth-seeded variety the cross-fertilized seeds were yellow.

By using these and other characters which clearly indicate the source of the pollen, data were obtained which include

counts of nearly one hundred thousand individuals. From these figures the surprising superiority of self-pollination stood out clearly. In some mixtures less than two per cent. of the seeds produced were cross-fertilized, whereas with random fertilization fifty per cent. on the average should be of that type. This same result has been obtained from several species widely separated in the plant kingdom and proves that where differences exist more offspring result from the plant's own kind of pollen than from that of any other source, even though the differences are small and only in apparently minor qualities. This is true notwithstanding the fact that these same plants are perfectly fertile when the different kinds of pollen are not in competition.

Although bizarre and astonishing plant hybrids are regularly recorded in the newspapers, horticulturists are fully aware that only closely related species are fertile when interpollinated and that crossing different species seldom produces good seed. When plants are grown from such hybrid seed they are rarely fertile. Plants are as restricted in reproduction as are animals, and even in those cases, previously mentioned, where self-fertilization is reduced or prevented, it is probable that crossing within is favored rather than crossing out of the type.

With this evidence from the corners of the phylogenetic triangle—seed plants, protozoa and man—that there is a definite tendency to establish a caste system throughout nature, why should we apologize for our pride of race and of family? Is it not rather something to be fostered and maintained? Restricted marriages are customary in nearly all social groups and many savage tribes have very strict taboos against marrying out of the clan.

In India the caste system has reached its most extreme development. The members of each occupational group are forbidden to marry into any other group. Farmers can not marry the daughters of shopkeepers. The families of school teachers, bankers and manufacturers are each limited in their choice of husband and wife to the members of their own trade. It is not apparent how such artificial barriers can work to the best interests of the race, and it seems that an over-refinement, bordering on absurdity, has been reached in that country.

This should not obscure the fact that the ability to retain superiority when once established is a primary necessity in racial progress and the mating of like with like is a natural law too deep-seated and too well established to be set aside by political systems.

The practice in this country is much more sound, biologically. Marriage is as severely restricted to members of the same social level as in any other country, but individuals change from one level to another according to their ability to demonstrate their true worth. There are many exceptions to this, of course, but the general tendency is plain. Owing to inherited wealth and its accompanying social advantages the weeding-out process is not so effective as might be desired. The inheritance tax has eugenic significance. But even under the present system, wealth vanishes unless accompanied by intellectual integrity, while titles remain to embarrass those forms of government which still cherish them.

Concern is often expressed lest legal barriers be removed and marriages between different races be encouraged, as if statutes were the only preventive of miscegenation! Authorities disagree as to the harm and benefits of race-crossing. Some say that the mating of racially different individuals of equivalent social standing is not so serious as the lowering of the standards of social groups within the race. Nature does not argue this point, but guards against both by a system of marital selection the foundations for which were laid in the lower forms of life and which has evolved with man himself.

GARA CHEURFA

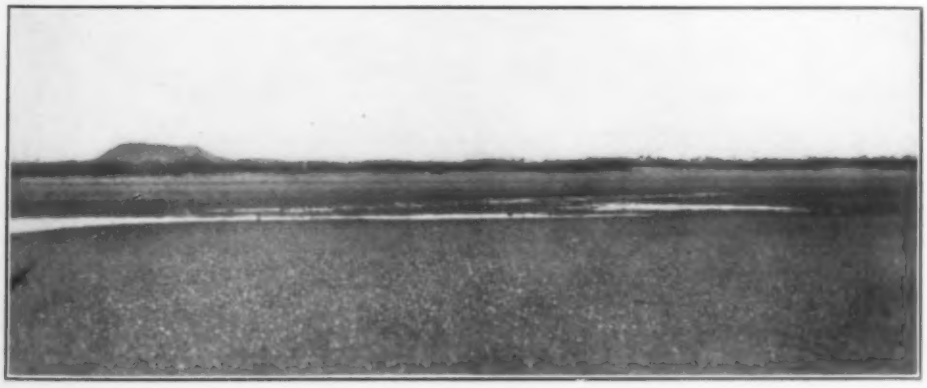
By ALONZO W. POND

ASSISTANT CURATOR LOGAN MUSEUM, LEADER LOGAN–SAHARA EXPEDITION, 1925 CAMPAIGN

THE desert traveler from the north and northeast descends from the plateau of Tademait, taking as his guide a table mountain, on the western end of which he sees a pile of stones, a signal cairn for weary caravans which marks the direction of the Arab village Aoulef Cheurfa, three days by camel west of InSalah, in the Sahara Desert. For the geologist that signal rock is just one of the isolated remnants of the Tademait plateau which he will tell you is composed of very hard sandstone formed millions of years ago. Millions of years have worked their changes out here in the Sahara, and ancient rivers, sand-laden winds and extreme changes in temperature have cut away much of the great plateau, leaving here and there isolated remnants, steep-sloped mountains which stand like great stone monuments of forgotten ages. The Arab name for these steep-sided remnants of ancient plateaus is Gara, and the Gara which marks the direction of the village of the Cheurfa tribe is called the Gara Cheurfa.

In the depression west of the flat-topped mountain the Cheurfa have planted their date palms, which they irrigate with water carried by long tunnels from the plain to the west. Their tunnels are dug in the clay at the water level and slope toward their palm groves so that the water which has fallen in the mountains hundreds of miles to the north is here collected and carried in artificial channels until it reaches the surface in the depressions and can be used to water palm trees and garden beds of wheat and vegetables. Great dunes of sand on the north and east of the palm grove protect it from the cold winds and constantly threaten to bury the oasis.

Seven centuries the Cheurfa have lived in the shadow of the Gara Cheurfa, for historic records give their arrival from Morocco and the founding of the village Aoulef Cheurfa in the latter half



GARA CHEURFA SEEN FROM THE DISTANCE.

AOULEF CHEURFA, OASIS AND VILLAGE SEEN FROM THE GARA.

of the thirteenth century. Perhaps it was those first arrivals from Morocco who found fresh water in the crevice just below the summit of the eastern end of the Gara and called that water hole "Mother of People Spring" because it supplies drink to the desert traveler who passes that way. Natives tell us that the "spring" has long been dry and scientists smile, saying, "Because it is a long, long time since it has rained here. Your spring is just a natural cistern." The summit of the Gara slopes east, so that whatever rain falls must collect in any depression at the eastern end of the mountain; as this hollow is covered with big rocks it is protected from evaporation and water stands there for many weeks.

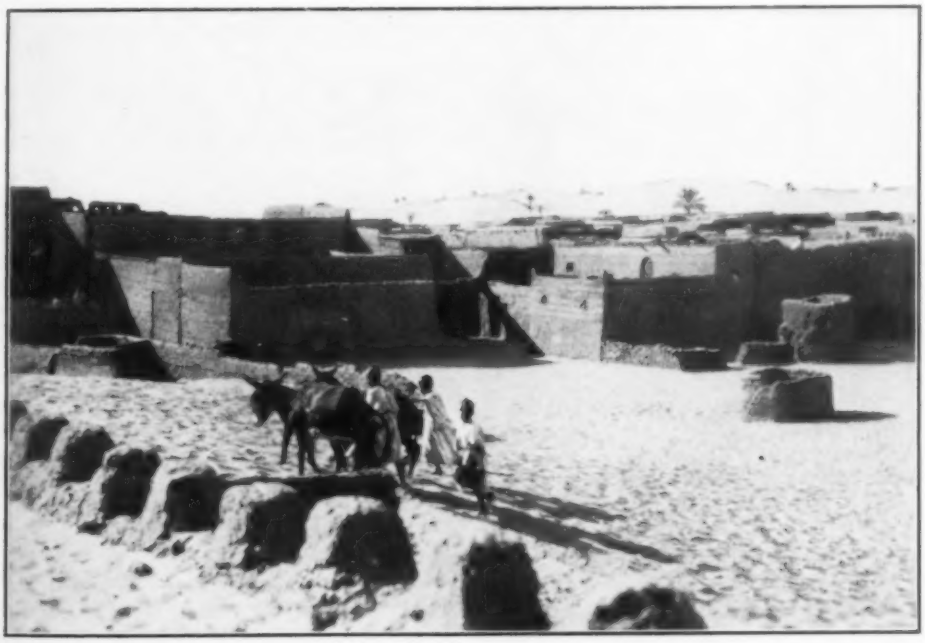
We know that Gara Cheurfa was a meeting place of more ancient peoples than the thirteenth century Cheurfa, for on the western slope gigantic blocks of the hard sandstone, broken off from the mountain, are covered with inscriptions in tifinar characters, the writing of the ancient Libyans and of the modern Tuaregs. Here and there among the inscriptions are carved crude camels and cruder representations of men. In 1903 these inscriptions were copied and translated by a French officer, so we know their significance, a meeting place for the Tuaregs long before the arrival of the Arabs from Morocco.

In recent years it has served as a place for religious gatherings. A Marabout or priest, who the natives tell us "came from another village," frequently summoned the people living in the vicinity of the Gara to prayer. A long trench, still visible, served as the line at which the crowd assembled before the priest and prayed.

There are mysteries about the flat-topped mountain that overlooks the village of Aoulef, for on rare occasions the inhabitants say, "the mountain fires a

gun." The year that the French captured InSalah the villagers heard the noise of the cannon coming from the Gara, and this year in October the same report was heard. "It is the spirits of the earth who shoot," is the simple explanation of the Arabs, but science names the spirits *heat* and *cold*. All around the Gara are great blocks of stone broken from the mountain. Some have fallen down the slope and others only slipped a foot or so, leaving straight-sided fissures which are so regular that they must be artificial. The constant expansion and contraction of the rocks caused by the extremely hot days and extremely cold nights eventually splits off pieces. Although such splitting probably happens often it is only on rare occasions, when the variations of temperature are exceptionally extreme and a huge block of rock breaks away, that the noise is loud like the report of a cannon. Some of these great blocks are so placed or their composition is somewhat different so that when they are struck with another stone or club they ring like a well-cast bell. On fête days the natives frequently add the ring of Gara Cheurfa rocks to the rumble of their palm trunk drums to call the crowd to feast and play.

How the spirits of that ancient rock must smile and chuckle at the efforts of the people who live in its shadow and of us who have traveled thousands of miles to learn its secrets! Some of the secrets of the Gara we can read to-day as easily as we read the daily paper, but unfortunately the date of publication and the name of the editor as well as his nationality seems to remain a secret of the Gara spirits. The secrets we read are told us by the stone implements found by the Logan Sahara Expedition of Beloit College on a plain a mile east of the Gara Cheurfa. This plain the geologists tell us (Professor E. Gautier, Uni-



THE VILLAGE OF THE CHEURFA.

versity of Algiers) is a quaternary formation. Thousands of years ago water, probably as a river, cut its way down through that ancient plateau of Tademait. When the Sahara dried up, the winds got their clear sweep across the plain, and they carried all the loose sand away to pile it up as dunes in the lower depressions and left only a hard-packed sandy clay plain which geologists call a reg. The gravel stones which had been rolled by the water could not be blown away with the sand and rest on the surface of the reg. For thousands of years the sand-laden winds have cut and polished these pebbles so that it is not uncommon to find some worn flat on the side exposed to the weather.

It is in this quaternary reg six inches below the surface and four above bedrock that the expedition found fifteen coarse, heavy stone picks. In shape they are long, narrow triangles with thick rounded bases. The edges are slightly wavy, like the fist hatchets found in European paleolithic stations of the late Chellean or early Acheulian period. But in Europe these deposits also contain animal remains, the bones of extinct animals which permit the scientist to know something of the climate which existed at the time the deposits were made and with that information to form a fairly definite idea of what part of the geologic epoch they belong in. In this little station near Gara Cheurfa there is not a trace of animal remains, not a hint of a hearth, nor a sign of any other ancient industry, above or below. There is only the form of the implements, but fortunately that is typical. The material of which they are made is coarse and they are covered with a heavy crust which thousands of years laying in sand and clay has added since the people who made them lived. No flakes of that coarse sandstone material were found in the deposit, nothing but the few picks or fist hatchets and these were not close

IRRIGATING TUNNEL EMPTIES ITS WATER INTO THE PALM GROVE.

MOHAMMED DESCENDS FROM THE GARA WITH A LOAD OF SPECIMENS.

enough together to be considered as an intentionally hidden lot or cache. Not a single one of the bits of other rock found in the same trenches showed any sign of having been worked by man nor did they have the slightest semblance of definite intentional form. The bedrock formation above which the implements were found adds interest but gives no clew to the exact age of the pieces. Who made the picks found in this isolated part of the desert, a mile from the faintly traced ancient river bed and a mile from the Gara?

There is a strong probability that the descendants of the beings who made these crude picks were to be found in the region for many hundreds of generations. On the summit of the Gara, scattered over the surface at the west end, the expedition found pieces of the hard sandstone which showed evidence of having been shaped by an intelligent being. We spent many hours searching the top of that table mountain and collected about three hundred pounds of stones which have served as tools to prehistoric peoples, among them three large disks which are the cores left after the flakes have been struck off for making smaller implements and which themselves have probably served as cleavers. Smaller disks of which we found several, may have served as scrapers, and three which were found together in a trench about eight inches below the surface have been chipped in the same manner. Each has the same peculiar hollow at one side. These, however, are not made of the coarse sandstone but of petrified wood and are so regular and uniform that it leads us to think that the prehistoric people who made them wrapped them in bits of skin and with a short leather thong attached them to a long leather rope and used the contraption to catch animals with much as the South Americans use a three-balled bolo. Whirling

ANCIENT WRITING ON THE ROCKS OF GARA CHEURFA. NOTE SPLIT CAUSED BY HEAT AND COLD.

the rope with its three heavy ends around their head they let it fly at the feet of the running animal. The three weighted ends wrap around the legs of the beast and either stops him or hinders his progress so that the hunter is able to capture and kill him. Whether the ancient inhabitants of Gara Cheurfa used such a weapon or not we can not be certain, but finding three stones exactly alike and all obviously shaped by man permits interesting speculation on that point at least.

There are flat-sided points, coarse and rather thick at times, but all show artificial chipping on the edges which gives them their intended shape. A few hard pebbles of material entirely different from the formation of the Gara and which have been brought from the plain below show the battered edges character-

istic of stones which have been used to break up other rocks with—hammer stones, we call them. But perhaps the most interesting are the number of triangular picks or hatchets with rounded bases. These are much more regular in form and the flaking on the edges much finer so that the edges are straight and not wavy. They are of the same material as the picks found down on the plain and which from their form and the technique of their manufacture we believe belong to the early part of the Old Stone Age or more particularly Chellean or early Acheulean period of archeology, made of the same material and similar in shape but showing much finer technique and skill in workmanship. Are they simply a later product, later by many thousands of years, it is true, but a product of the same race of people who made the coarser implements found only a mile away?

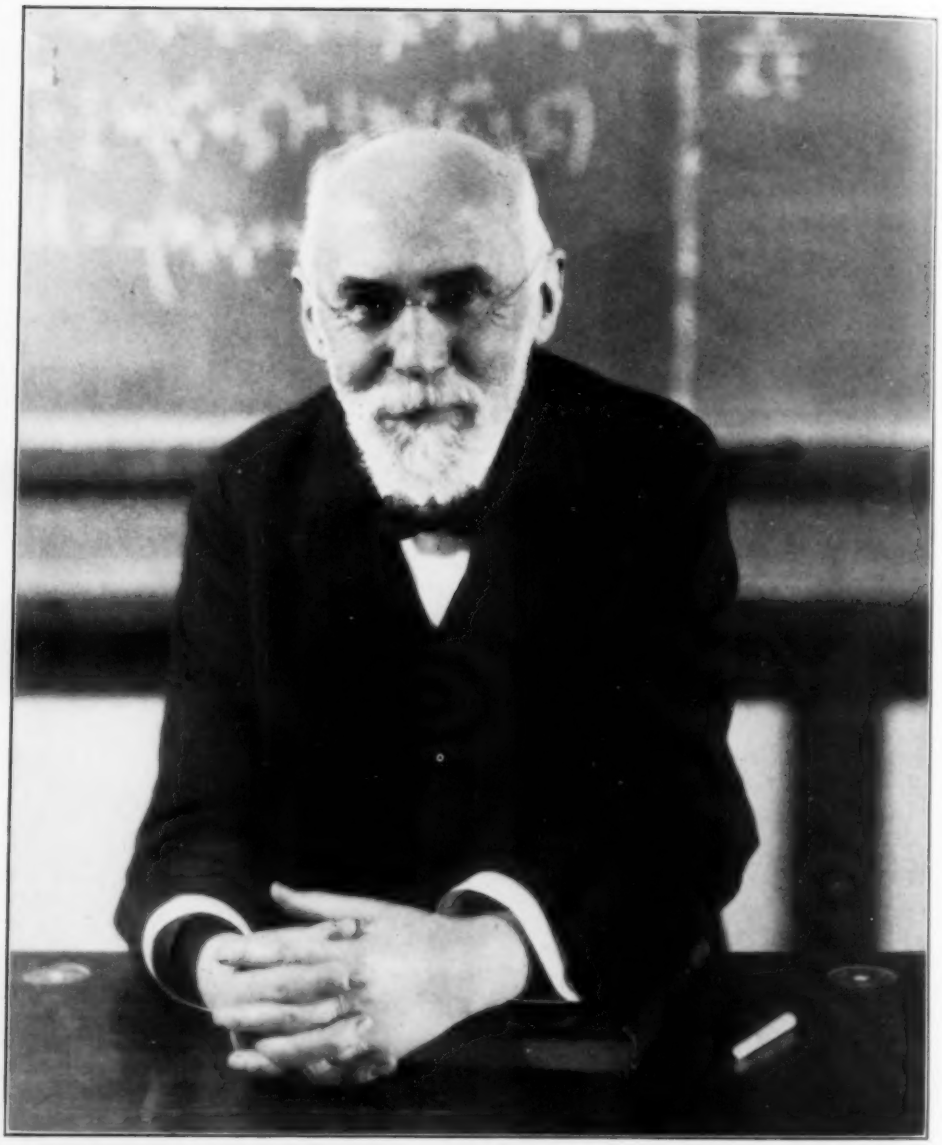
In Europe we have found many of the flat-sided scrapers and points, some of which were probably used as spear points, and with them the same sort of disks and even the small identical "bolo" stones; but in Europe the deposits in which they are found also contain the remains of feasts and fireplaces so that the industry has been carefully studied and its place in the world's progress well established. In Europe no one would hesitate to say that these worked stones belonged to the Mousterian period of the Old Stone Age, but here in the Sahara we have no animal remains to help us identify the age of the implements, and in the same deposit with the characteristic Mousterian pieces we find the fist hatchets which are typical of the late Acheulean culture. Perhaps the people who lived on Gara Cheurfa a hundred thousand years ago (unfortunately there is absolutely nothing by which we can date the industry even as to its place in geological periods) were the descendants of those who made the cruder hatchets of the plain, and we

MOTHER OF PEOPLE SPRING ON GARA CHEURFA.

NEGRO CITIZENS OF AOULEF CHEURFA CARRYING DATES.

might call their industry a Mousterian culture with Acheulean tradition. What is the relation of this industry in the heart of the Sahara Desert to similar techniques in Europe? The forms of implements found on the two continents are so similar that one recognizes the characteristics at once. Perhaps further study and other discoveries will answer the question for us.

If we can not date the industry of Gara Cheurfa we have at least discovered that at some time in the distant past a people lived here in the Sahara who made flat-sided spear points, disk-like cleavers and small throwing stones very much like the people who lived in Southern Europe a hundred thousand years ago . . . the Mousterians and the late Acheuleans What became of those people? Did their descendants migrate to the north and south? Did they remain in the region or did they just die off gradually? Those are some of the questions the spirits of Gara Cheurfa could answer if we could understand their language and they would tell their secrets.



HENDRIK ANTOON LORENTZ

THE PROGRESS OF SCIENCE

HENDRIK ANTOON LORENTZ

AMONG the small group of physicists to whom the chief credit is due for the rapid and revolutionary advances in physical science during the last thirty years, Hendrik Antoon Lorentz, who died on February 5 at the age of seventy-six years, occupied a prominent place. He was a pioneer in the general field that is suggested when the electron is mentioned, and predicted some of the most important properties of the electron before electrons were discovered or even named. It was for work in this field that he received the Nobel prize about twenty years ago. He took a prominent part also in the discussions regarding the effect of relative motion between matter and ether and in treating the whole series of puzzling questions that were raised by the failure of the Michelson-Morley experiment to give positive evidence of such motion. It was Lorentz who showed the way in which the mass of a moving electric charge depends upon its velocity; and upon the assumption, now universally accepted, that all matter is made up of electrical charges he showed that not only the mass but also the dimensions of a moving body must depend upon its speed. Although his work was based upon the assumption of a quiet ether—now generally abandoned—it led to the same results that were afterward obtained on the basis of the theory of relativity; so that he is to be regarded as a pioneer in this field also. In fact during his long tenure of the professorship of theoretical physics at the University of Leyden he made important contributions to almost every branch of physics. At the jubilee celebration held in his honor two years ago the most distinguished physicists in Europe, many of them his former students, were present to extend to him their congratulations.

Professor Lorentz was the representative of Holland on the Committee of the League of Nations on Intellectual Cooperation and at the time of his death was chairman of this committee.

He has made several visits to this country. A series of lectures delivered at Columbia in 1906 formed the basis of a book on electron theory which is still the standard treatise on this subject. In 1920 and again in 1927 he spent the winter quarter at the California Institute of Technology. The portrait here reproduced was taken by Mr. Troy at the close of a series of thirty lectures at Cornell in 1926. Modest and unassuming, broad in his interests and activities, kindly and sympathetic in all his dealings, Professor Lorentz made a deep impression on all with whom he came in contact.

E. M.

THE REVOLUTION IN PHYSICS

SIR OLIVER LODGE delivered the Kelvin lecture to the Institution of Electrical Engineers on April 20. He said, according to a report in the London *Times*, that the revolution in physics during the present century was such that mathematical speculators were soaring up into the clouds of tensors and matrices and imaginary operators, and any number of dimensions of space. They dropped perturbing bombs, which when opened contained interesting things, more like seeds than explosives, and those that took root flourished exceedingly. The bombs of the quantum and of relativity were already rooted, accepted and cultivated, and had led to gravitational and electromagnetic extensions. The older method

PROFESSOR AIKITU TANAKADATE

IN HIS LABORATORY OF AERONAUTICS AT THE UNIVERSITY OF TOKIO

was to plant a seed quietly in the ground, so that its growth could be watched. Radioactivity was one, the electron was another, of those quiet and most fruitful seeds; the Bohr theory of the spectrum was yet another. But how to regard the Schrödinger waves was still a question; in a sense they had developed out of the quantum, but they were more revolutionary than that; while the latest Heisenberg and Dirac bombs were still, he supposed, under examination, and had still to prove their fertility.

Meanwhile wave-mechanics represented the beginning of a comprehensive theory of the ether, which must be contemplated by every one interested in physical reality. If it was a heresy to believe in the FitzGerald Contraction and other things, including the ether, as realities and not merely conventions to suit different observers, then he was a heretic. That a mathematician should be content with the Lorentz Transformation, without seeking to go behind it or interpret it physically, otherwise than from the point of view of various observers, was intelligible enough. But a physicist could not be so easily and pragmatically satisfied. The β factor in the Lorentz Transformation was not in it at first, and then it was not reciprocal. The introduction of the β factor completed the transformation, and that factor was the FitzGerald Contraction pure and simple.

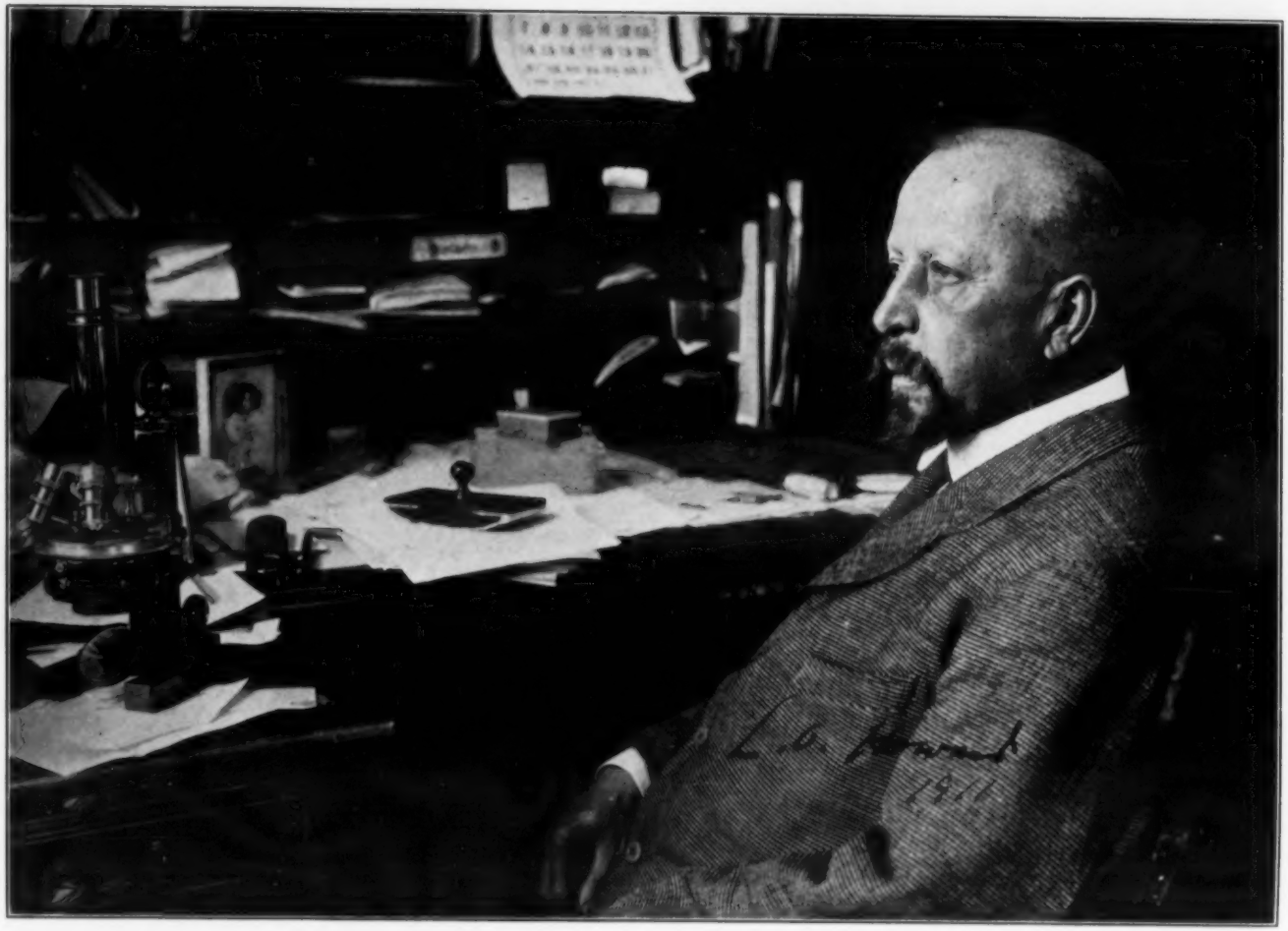
When a body radiated energy it must lose mass. It could not lose mass continuously, for mass was electric charge, and that was discontinuous. Mass could only be lost in particles, hence energy could only be radiated in quanta. Continuous radiation was impossible: it must occur in jerks. It could only be smoothed out on the average by dealing with an immense number of particles—just as gaseous or liquid pressure on the average was uniform, though really intermittent and jerky, as was shown by the Brownian movement when the bombarded surface was small enough.

There might be several different ways of regarding the same essential thing. Electric and magnetic explanations could never be ultimate so long as they could be resolved into something mechanically simpler. A vortex fluid, in which the laws of dynamics held in the innermost parts, however much they might appear departed from in the gross, was about the simplest view of the substratum of the physical universe that could be imagined, in spite of the difficulty of treating it mathematically. It would be time to try to imagine something else when that conception had been proved finally wanting or irrevocably false.

THE FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

The first International Congress of Entomology was held in Brussels in 1910, the second congress was held at Oxford in 1912, the third at Zurich in 1925, while the fourth is to be held in Ithaca at Cornell University during the coming summer from August 12 to 18, inclusive. Unquestionably past congresses have contributed much to the advancement of the science of entomology and to friendly intercourse among the scientists of the different countries, the influence of which has certainly contributed its mite toward a better understanding and a more mutual respect between the peoples of the different nations involved; and there seems to be no reason why the coming congress at Ithaca should not be equally effective in advancing the science of entomology and in promoting international good will.

There is every indication at the present time that the fourth congress will



DR. L. O. HOWARD

PRESIDENT OF THE FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY.

be more largely attended than any one of the preceding congresses. This is due partly to the fact that this country and Canada have so large a number of entomologists who will be in attendance, partly to the fact that many of the foresters of this country are interested in entomology and will attend the sessions on forest insects, and partly to the fact that financial resources have been made available for aiding foreign entomologists to come to America. This latter condition assures the congress of a most satisfactory attendance by European entomologists, with especially large delegations from Britain and Germany. Of the more remote countries of the world Russia will be represented by at least six prominent scientists, China and Japan by official delegates, Australia by Dr. R. J. Tillyard, Argentina by Dr. F. Lahille, Chine by A. M. Graf, Mexico by Dr. A. Dampf, while other countries have signified their intentions of sending representatives.

The local committee, in consultation with American entomologists in various phases of the science, has formulated a tentative program based largely on the arrangement of the program of the congress in 1925 at Zurich. There will be four general forenoon sessions at which papers of broad interest will be presented by the leading entomologists of the world. The afternoons will be devoted to discussions of the following more specialized subjects: taxonomy, distribution, nomenclature, morphology, embryology, physiology, ecology, medical and veterinary entomology, geneties, economic entomology and apiculture. The great host of insect forms, their structure, relationships, remarkable transformations, habits, lives and reactions, their relation to man in carrying causative organisms of disease, their rôle in the destruction of fruits, cereals and vegetables, their injuries to domestic animals and to our great forests will be discussed from all angles in a broad comprehensive way.

The sessions for the reading of papers will be held in Baker Hall, the new chemical laboratories of the university, where lecture rooms of various capacity are available and where every facility for displaying charts and showing lantern slides is afforded. The headquarters of the congress for registration and information will be maintained in Willard Straight Hall, in which visitors will find comfortable sitting rooms, reading rooms and convenient dining rooms and cafeterias. Tea will be served here every afternoon from 4 to 5:30. The department of entomology with its lecture rooms and laboratories is situated in Roberts Hall, where visiting entomologists will be welcomed. The extensive collections of the department are also housed here and are available to any one interested.

Arrangements are being made for excursions to nearby points of scenic interest as well as to localities for collecting. A special excursion, at reduced rates, to Niagara Falls will be arranged, while plans for a trip to Pittsburgh, Philadelphia, Washington, the Japanese beetle laboratories at Moorestown, N. J., and New York, to Boston and vicinity are in process of formation.

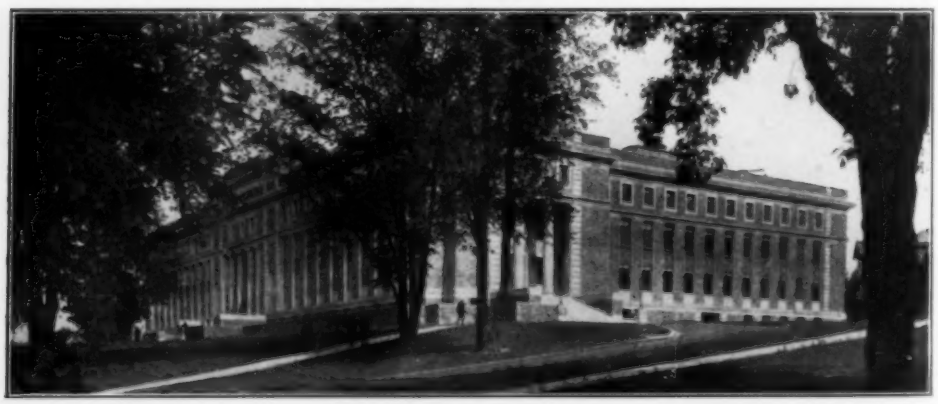
The permanent committee of the congress is as follows: Dr. Karl Jordan, of Tring, England, permanent secretary, with Dr. Walther Horn, of Berlin-Dahlem; Dr. Y. Sjostedt, Stockholm; Dr. R. Jeannel, Paris; Dr. H. Eltringham, Oxford, and Dr. L. O. Howard, Washington, D. C., as the remaining members. All these men are planning to be present at the congress and will contribute papers. Dr. L. O. Howard, for so many years chief of the United States Bureau of Entomology, is president of the congress, while Dr. A. O. Johannsen, of Cornell University, is American executive secretary. The members of the

DR. L. O. HOWARD
PRESIDENT OF THE FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY.

ROBERTS HALL

HEADQUARTERS OF THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY. THE DEPARTMENT OF ENTOMOLOGY IS HOUSED IN THE CENTER BUILDING.

American Organization Committee consist of representative entomologists and include Dr. E. D. Ball, entomologist of the State Plant Board of Florida; Dr. P. P. Calvert, University of Pennsylvania; Dr. J. G. Holland, of the Carnegie Museum, Pittsburgh; Dr. F. E. Lutz, of the American Museum of Natural History; Dr. J. G. Needham, Cornell University; Professor Herbert Osborn, Ohio State University; Dr. A. W. Baker, Ontario Agricultural College, Guelph, Canada; Dr. W. H. Brittain, McDonald College, Quebec, and Mr. Arthur Gibson, Dominion entomologist of Canada. G. W. H.



BAKER HALL

THE NEW CHEMICAL LABORATORY IN WHICH THE TECHNICAL SESSIONS OF THE CONGRESS WILL BE HELD.

INDEX

NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

Abbot, Charles Greeley, Portrait, 280
ADAMS, W. S., The Interior of a Star, 363
Airplane Safety, 379
AITKEN, R. G., Edward Emerson Barnard, 263
American Association for the Advancement of Science, Nashville Meeting, 87, 183
Animal Husbandry and War, S. HILLYARD, 244
Archaeopteryx, Restoration of, H. FRIEDMANN, 178
Astronomical Observatory Buildings, Four Old, F. CAJORI, 372
Atom as a Source of Energy, A. HAAS, 140
Atomic Theory, Recent, R. B. LINDSAY, 299
AULT, J. P., Ocean-surveys, 160

Bacon and the Novum Organum, J. WRIGHT, 34
Bailey, L. H., Portrait, 88
BANGSTED, H., A Winter Sledging Expedition on the Inland Ice of Greenland, 253
Barnard, Edward Emerson, Portrait, 262; R. G. AITKEN, 263
BEARD, J. H., The Gastronomy of Colonel Carter of Cartersville, 346
Bechterev, Vladimir, Portrait, 444
Biggs, Hermann M., Portrait, 381
BING, F. C., John Lining, 249
Biophysics, Advances in, 189
Birds and Injurious Insects, E. H. STRICKLAND, 48
Borodin, Ivan P., Portrait, 436
Botanical Explorations in the Rocky Mountains, J. E. KIRKWOOD, 315
BROWN, F. C., Building a Museum, 193

CAJORI, F., Four Old Astronomical Observatory Buildings, 372
CARLTON, F. T., Psychology and Management, 350
Cathode Ray Tube, the Nine-Hundred-Thousand Volt, 380
CAUDELL, A. N., Grasshoppers and their Allies, 329
CHAPIN, C. V., Epidemic Diseases, 481
Chemist, The, How it is done by, D. B. KEYES, 217
Coolidge, W. D., Portrait, 382
Cosmogony, Wider Aspects of, J. S. JEANS, 454
Crime, The Control of, E. A. DOLL, 551

Darwin, House at Downe, 90; at Home, Portrait, 91; on Spencer, B. J. STERN, 180
Diet and Disease, T. S. HARDING, 150
Diseases, Epidemic, C. V. CHAPIN, 481
DOLL, E. A., The Control of Crime, 551
DOWNING, E. R., Scientific Thinking, 231
DUMBLE, E. T., (The late), The Oil Game, 541

EARP, J. R., Tobacco and Scholarship, 335
Electrons and Wave Motion, 475
Engineering Laboratory for Lehigh University, 384
Entomology, International Congress, 571
EYCLESHYMER, A. C. (The late), Growing Old and the Search for an Elixir of Life, 400

Fabre's Harmas, A Visit to, G. W. HERRICK, 494; Portrait, 497
FAIRCHILD, D., Two Expeditions after Living Plants, 97
FAIRCHILD, H. L., Ward's Natural Science Establishment, 468
Fewkes, J. Walter, Retirement, 377, Portrait, 378
Fibiger, Johannes, Portrait, 94; Work on Experimental Production of Cancer, 95
FORD, W. W., Work of Joseph Lister, 70
Forests and Grazing, C. W. TOWNSEND, 57
FRIEDMANN, H., Restoration of Archaeopteryx, 178

Gara Cheurfa, A. W. POND, 561
Gastronomy of Colonel Carter of Cartersville, J. H. BEARD, 346
Genetics, Mammalian, C. C. LITTLE, 521
Gibbs, Willard, J. JOHNSTON, 129
Grasshoppers and Their Allies, A. N. CAUDELL, 329
GUDGER, E. W., An Ocean Sunfish, 257

HAAS, A., The Atom as a Source of Energy, 140
HARDING, T. S., Diet and Disease, 150; Cod Liver Oil Therapy, 338
HAYES, E. C., Racial Groups in a University, 158
HERING, D. W., Scientific Fantasies, 430
HERRICK, G. W., A Visit to Fabre's Harmas, 494
HEYL, P. R., Wave Mechanics, 41; Visions and Dreams of a Scientific Man, 514
HILLYARD, S., Animal Husbandry and War, 244
Howard, L. O., Portrait, 572

Internal Secretions in Evolution and Reproduction, O. RIDDLE, 202

JEANS, J. H., Wider Aspects of Cosmogony, 454
JOHNSTON, J., Willard Gibbs, 129
JONES, D. F., Like Father Like Son-in-law, 557

KENNELLY, A. E., The Metric System, 147
KEYES, D. B., How it is done by the Chemist, 217
KIRKWOOD, J. E., Botanical Explorations in the Rocky Mountains, 315

LAURENS, H., Radiant Energy, 353
Life, Elixir of, Search for, A. C. EYCLESHYMER, 400

Like Father Like Son-in-law, D. F. JONES, 557
LINDSAY, R. B., Recent Atomic Theory, 299
Lining, John, F. C. BING, 249
LIPMAN, C. B., The Chemical Elements Indispensable to Plants, 289
Lister, Joseph, W. W. FORD, 70
LITTLE, C. C., Mammalian Genetics, 521
Living Longer: Medical Viewpoint, H. V. WÜRDEMANN, 535; Sociological Viewpoint, R. D. MCKENZIE, 537
Locomotion, Bodily, The Influence of, in separating Man from the Monkeys and Apes, H. F. OSBORN, 385
Lorentz, Hendrik Antoon, Portrait, 568; 569
LORENZ, A. J., Pharaoh's Doctor, 306

MACDOUGAL, D. T., Plant Physiology, 464
MCKENZIE, R. D., Can We Live Longer?, A Sociological Viewpoint, 537
Mathematics, Origin of, G. A. MILLER, 295; Modern, R. E. MORITZ, 412
Maximow, Nicholas A., Portrait, 440; Mrs., 442
MAYER, J., America's Influence on the Development of the Sciences, 60
Mechanics, Wave, P. R. HEYL, 41
Metric System, A. E. KENNELLY, 147
MEYER, A. W., Science and Conduct, 222
MILLER, G. A., Origin of Mathematics, 295
MORITZ, R. E., Modern Mathematics, 412
Museum, Building a, F. C. BROWN, 193; of Natural History, American, School Service Building, 285
Music from the Ether, 283

Nigeria, A. S. PEARSE, 5
"Nitrogen Cycle" in Education, W. H. STONE, 426
Noyes, Arthur A., Portrait, 89, 186

Ocean-surveys, J. P. AULT, 160
Oil Game, E. T. DUMBLE (The late), 541
Optical Glass Disk, Casting an, 479
OSBORN, H. F., The Influence of Bodily Locomotion in separating Man from the Monkeys and Apes, 385
Osborn, Henry Fairfield, Portrait, 187

Palissy, Bernard, Portrait, 28; G. M. ZIEGLER, 29
Pavlov, Ivan P., Portrait, 446
PEARSE, A. S., In Nigeria, 5
Pharaoh's Doctor, A. J. LORENZ, 306
Pharmacy and Science, Philadelphia College of, 287
Physics, Research in, at Yale University, 281; The Revolution in, 569
Plant Physiology, D. T. MACDOUGAL, 464
Plants, Living, Two Expeditions after, D. FAIRCHILD, 97; Chemical Elements Indispensable to, C. B. LIPMAN, 289
POND, A. W., Gara Cheurfa, 561
Progress of Science, 87, 182, 279, 377, 473, 569
Psychology, International Congress of, 188; and Management, F. T. CARLTON, 350

Racial Groups in a University, E. C. HAYES, 158
Radiant Energy, H. LAURENS, 353
Richards, Theodore William, Portrait, 472, 473
RIDDLE, O., Internal Secretions in Evolution and Reproduction, 202
Rittenhouse, David—Pioneer American Astronomer, W. C. RUFUS, 506
RUFUS, W. C., David Rittenhouse—Pioneer American Astronomer, 506
Russia, Science in, W. SEIFRIZ, 433
Rutherford, Sir Ernest, and Lord Haldane, Portrait, 286

Science, and Conduct, A. W. MEYER, 222; and History, L. THORNDIKE, 342
Sciences, America's Influence on the Development of, J. MAYER, 60
Scientific, Thinking, E. R. DOWNING, 231; Fantasies, D. W. HERING, 430; Man, Visions and Dreams of, P. R. HEYL, 514
SEIFRIZ, W., Science in Russia, 433
Sledging Expedition, Winter, on the Inland Ice of Greenland, H. BANGSTED, 253
Smithsonian Institution, the Secretary of, 279
Social Taboo, K. YOUNG, 449
Star, the Interior of, W. S. ADAMS, 363
STERN, B. J., Darwin on Spencer, 180
STONE, W. H., The "Nitrogen Cycle" in Education, 426
STRICKLAND, E. H., Birds and Injurious Insects, 48
Sunfish, Ocean, E. W. GUDGER, 257
Sweetness, The Race for, J. J. WILLAMAN, 76

Tanakadate, Aikitu, Portrait, 570
Therapy, Cod Liver Oil, T. S. HARDING, 338
Theremin, Leon, Portrait, 284
THORNDIKE, L., History and Science, 342
Titchener, Edward Bradford, Portrait, 282
Tobacco and Scholarship, J. R. EARP, 335
TOWNSEND, C. W., Grazing and Forests, 57

Vavilov, N. J., Portrait, 438
VIOSCA, P., JR., Wild Life in Louisiana, 19

von Wagner-Jauregg, J., Nobel Prize Winner, 190; Portrait, 191
Ward's Natural Science Establishment, H. L. FAIRCHILD, 468
Wild Life in Louisiana, P. VIOSCA, JR., 19
WILLAMAN, J. J., The Race for Sweetness, 76
WRIGHT, J., Bacon and the Novum Organum, 34
WÜRDMANN, H. V., Can We live Longer? A Medical Viewpoint, 535

YOUNG, K., A Social Taboo, 449

ZIEGLER, G. M., Bernard Palissy, 29

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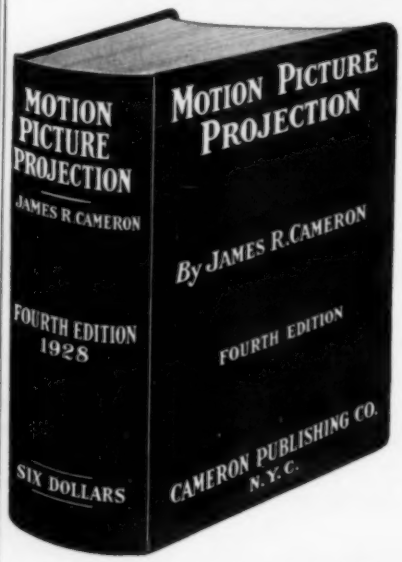

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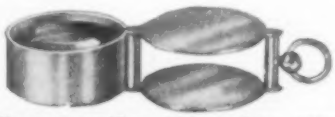

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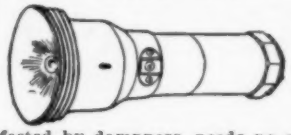

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